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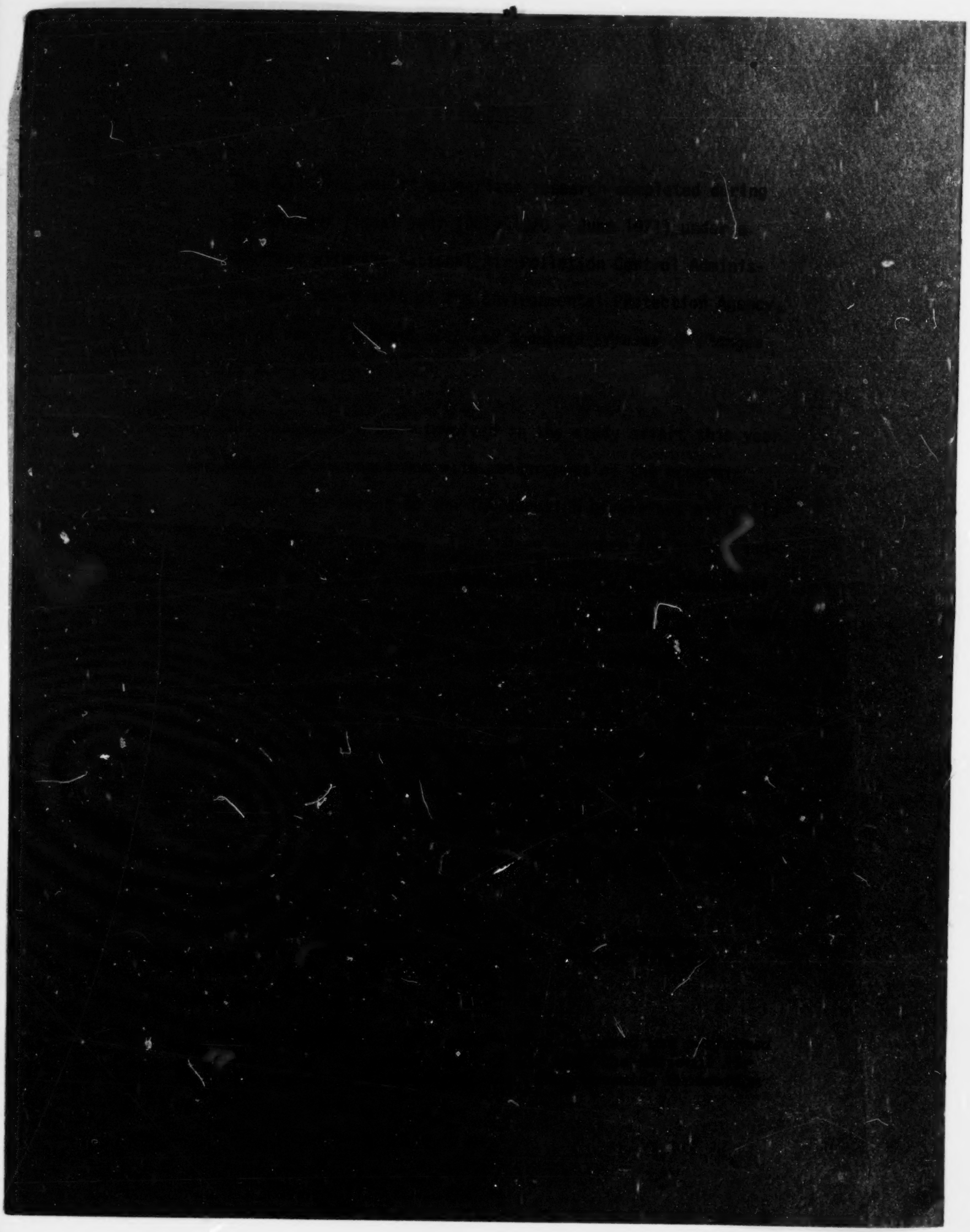

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16. Abstracts

A 2-phase research effort is summarized in this report. The first phase is concerned with measurement of the economic changes consequent to the introduction of various air pollution control policies. Areas of specific concern in this phase are as follows: The pollution production function; measurement of the costs of regulating open field burning in the Willamette Valley; the impact of air quality variations on tourist related industries. The second phase deals with social effects. A theoretical model concerning the effects of air quality changes on peoples attitudes and mass media use patterns has been formulated as a means of measurement of change. Each of the following objectives which relate to this model, are discussed: 1. completion of interviews and evaluation of response rates; 2. completion of coding, key punching and varification; 3. completion of visibility measures; 4. analysis of air quality perceptions of respondents; 5. analysis planned for the forthcoming year.

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*ECONOMIC EFFECTS OF CHANGES IN AIR QUALITY*

*R. Charles Vars and Gary W. Sorenson*

## I. INTRODUCTION

Oregon dominates United States production of certain grass seed crops, in large measure because Willamette Valley producers adopted the annual practice of open field burning to control seed diseases and to dispose of harvest residues.

> "In 1968 Oregon produced 41 percent of the total U.S. grass and legume seeds on approximately 308,000 acres. The value of Oregon's total seed crop to farmers was about 31 million dollars. The Willamette Valley accounted for 25 million dollars, or nearly 81 percent of the total state seed crop value. Nearly 43 percent of the total state seed crop value was in Linn County.
>
> Grass seeds were grown on about 250,000 acres at a value of 26 million dollars. Of this amount 86 percent, or 22.4 million dollars, was in the Willamette Valley. About one-half (13 million dollars) was in Linn County.
>
> Ryegrass seed was grown on 134,000 acres in 1968 at a value of nearly 13 million dollars--almost one-half of the total value of grass seed sales. Essentially all of the U.S. ryegrass seed is produced in the Willamette Valley, with 75 percent being grown in Linn County. Most ryegrass seed is grown on poorly drained soils on which alternative uses are quite limited. About 65 percent (87 thousand acres) of all ryegrass acreage is annual ryegrass. Perennial ryegrass is grown on the remaining 35 percent (47 thousand acres).
>
> Cleaning, sacking, and handling added about 12 percent, or 3.7 million dollars, to the value of the 1968 total seed crop. Blending and small packaging of grass seeds has been increasing within Oregon in recent years." *

---

*Middlemiss, W. E. and R. O. Coppedge, *Oregon's Grass and Legume Seed Industry in Economic Perspective*, Special Report 284, Cooperative Extension Service, Oregon State University, Corvallis, April 1970. p. 7.

Unfortunately, although field burning provides an effective and low-cost method of residue disposal and disease control, it also produces smoke in sufficient volumes to constitute a major air pollution problem for Oregon authorities. In fact, the Department of Environmental Quality has recently reported that, despite the decline in complaints from 1969 to 1970, field burning remains its major source of citizen complaint. Although most complaints reported in Table I.1 came from individuals and groups in the Eugene area, locations in the mid-Willamette Valley - e.g. Salem, Corvallis, and Lebanon - generated relatively large increases in complaints in 1970 as field burning south of these cities was purposely increased over past years when southerly winds were forecast. Overall, the DEQ reported that smoke and visibility reduction were the most frequent causes of complaint.*

Table I.1

Field Burning Complaints Tabulated

| Received by: | 1968 | 1969 | 1970 |
|---|---|---|---|
| Department of Environmental Quality | 11 | 1645 | 306 |
| Mid-Willamette Valley Air Pollution Authority | 6 | 88 | 186 |
| Lane Regional Air Pollution Authority | 127 | 3409 | 1241 |
| Total | 144 | 5142 | 1733 |

Source: *Field Burning in the Willamette Valley-1970*, Department of Environmental Quality, Air Quality Control Division Report, April 8, 1971.

More objective evidence of visibility restriction, smokiness, and air quality deterioration during recent summers is reported in Tables I.2 and I.3 and section II of this report. Table I.2 shows that smoke occurs with increasing frequency at both Eugene and Salem as summer progresses. Table I.3 provides evidence that the 1970 DEQ burning program reduced smokiness and increased visibility in Eugene while producing opposite effects for Salem in August -- a finding consistent with the atatistical results we report in section II of this report.

---

*Department of Environmental Quality, Air Quality Control Division, *Field Burning in the Willamette Valley, 1970,* staff report dated April 8, 1971, pp. 3-5.

Table I.2

Visibility Data

| | June | | | July | | | August | | | September | | | October | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 68 | 69 | 70 | 68 | 69 | 70 | 68 | 69 | 70 | 68 | 69 | 70 | 68 | 69 | 70 |
| **Eugene** | | | | | | | | | | | | | | | |
| Smoky Days | 4 | 1 | 2 | 3 | 5 | 3 | 4 | 11 | 7 | 17 | 9 | 6 | 16 | 15 | 10 |
| Smoky Hours | 5 | 2 | 3 | 10 | 12 | 8 | 15 | 40 | 14 | 170 | 51 | 35 | 67 | 39 | 47 |
| **Salem** | | | | | | | | | | | | | | | |
| Smoky Days | 1 | 2 | 0 | 3 | 6 | 4 | 5 | 10 | 10 | 15 | 8 | 6 | 11 | 13 | 10 |
| Smoky Hours | 2 | 9 | 0 | 10 | 8 | 8 | 11 | 16 | 53 | 92 | 66 | 50 | 53 | 85 | 65 |

Note: Smoky days are those days showing a restriction to visibility at the airport by smoke only, haze only, or smoke and haze on one or more hourly observations.

Smoky hours are those hourly observations showing restrictions to visibility by smoke only, haze only, or smoke and haze.

A weather element is listed as restricting visibility when it reduces prevailing visibility to six miles or less.

Source: *Field Burning in the Willamette Valley-1970*, Department of Environmental Quality, Air Quality Control Division Report, April 8, 1971.

Table I.3

Smokiness in Salem and Eugene

| | Salem | | | Eugene | | |
|---|---|---|---|---|---|---|
| | 1968 | 1969 | 1970 | 1968 | 1969 | 1970 |
| June | | | | | | |
| Smoky Days | 1 | 2 | 0 | 4 | 1 | 2 |
| Smoky Hours | | | | | | |
| Visibility 6 mi. or less | 2 | 9 | 0 | 5 | 2 | 3 |
| Visibility 3 mi. or less | 0 | 1 | 0 | 0 | 0 | 0 |
| July | | | | | | |
| Smoky Days | 3 | 6 | 4 | 3 | 5 | 3 |
| Smoky Hours | | | | | | |
| Visibility 6 mi. or less | 10 | 8 | 8 | 10 | 12 | 8 |
| Visibility 3 mi. or less | 0 | 0 | 0 | 0 | 4 | 4 |
| Visibility 1 mi. or less | 0 | 0 | 0 | 0 | 0 | 1 |
| August | | | | | | |
| Smoky Days | 5 | 10 | 10 | 4 | 11 | 7 |
| Smoky Hours | | | | | | |
| Visibility 6 mi. or less | 11 | 16 | 53 | 15 | 40 | 14 |
| Visibility 3 mi. or less | 0 | 3 | 16 | 8 | 30 | 3 |
| Visibility 1 mi. or less | 0 | 0 | 0 | 0 | 10 | 0 |
| September | | | | | | |
| Smoky Days | 15 | 8 | 6 | 17 | 9 | 6 |
| Smoky Hours | | | | | | |
| Visibility 6 mi. or less | 92 | 66 | 50 | 170 | 51 | 35 |
| Visibility 3 mi. or less | 18 | 16 | 10 | 62 | 42 | 1 |
| Visibility 1 mi. or less | 0 | 0 | 0 | 6 | 4 | 0 |
| October | | | | | | |
| Smoky Days | 11 | 13 | 10 | 16 | 15 | 10 |
| Smoky Hours | | | | | | |
| Visibility 6 mi. or less | 53 | 85 | 65 | 67 | 15 | 10 |
| Visibility 3 mi. or less | 5 | 35 | 16 | 50 | 25 | 3 |
| Visibility 1 mi. or less | 0 | 0 | 0 | 8 | 3 | 0 |

Source: *Field Burning in the Willamette Valley-1970,* Department of Environmental Quality, Air Quality Control Division Report, April 8, 1971.

Since field burning takes place between mid-July and late September, the visibility reductions associated with this agricultural practice occur during the height of the tourist and resident-vacation seasons in the Willamette Valley. Given the popular and widely prevalent belief that the desirability of outdoor recreation-type activities varies directly with visibility, it is generally believed that field burning adversely affects the Valley tourist industries. It is presumed that air quality deterioration leads tourists and residents to select different activities, alter their expenditures, etc. Consequently, many argue that a complete ban or some other stringent regulation of open field burning may raise incomes of the owners of specialized resources in the tourist industries while simultaneously improving air quality in the Willamette Valley.

Of course, improvements in visibility obtained by legally restricting or completely eliminating open field burning would increase total costs per acre in producing grass seed (see Table I.4). However, since Oregon dominates U.S. production of grass seeds and produces those seeds on Willamette Valley land poorly suited to conversion to other crops, the full impact of regulating field burning cannot be accurately estimated with the partial equilibrium methodology typically adopted by benefit-cost analysts. As argued in our first annual report, a general equilibrium methodology must underlie an evaluation of alternative programs for restricting open field burning because such programs appear likely to change (1) production costs for individual seed growers, (2) market prices of certain seeds, (3) supplies of seed produced outside Oregon, and (4) agricultural land prices in the Willamette Valley.*

The first annual report outlined a regional general equilibrium model appropriate for our research objectives, specified testable hypotheses concerning which tourist and resident demands are affected by reduced visibility, and established the relationship between air quality and the derived demands for factors of production. This report extends our methodological discussion in the first report, presents the results of our empirical investigations of the pollution production function and the determinants of agricultural land values in the Willamette Valley in sections II and III, respectively, and describes the status of our project to the impact of air quality variation on tourist and resident consumption activities in section IV.

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*Section III.A of this report amplifies our earlier analysis and presents a methodology for measuring the costs associated with control of open field burning.

Table I.4

A summary of increases in total costs per acre over open field burning with alternative residue removal techniques on selected grass seed crops.

| Alternative Residue Removal Techniques | Annual Ryegrass $/A | Perennial Ryegrass $/A | Highland Bentgrass $/A | Fine Fescue $/A | Merion Bluegrass $/A |
|---|---|---|---|---|---|
| A. Incorporation of residues into the soil | $21-$26 | ------- | ------- | ------- | ------- |
| B. Mobile field incinerator | $5-$10 | $5-$10 | $5-$10 | $5-$10 | $5-$10 |
| C. Mechanical removal of residues followed by field sanitation a/ | | | | | |
| 1. Bunching and Field Bucking | $12-$16 | $11-$14 | $10-$12 | $10-$12 | $9-$11 |
| 2. Stack Former and Mover | $15-$25 | $13-$21 | $11-$17 | $11-$17 | $11-$15 |
| 3. Chopper-Blower and Hauling b/ | $43 | $34 | $25 | $25 | $22 |
| 4. Baling and Hauling c/ | $24-$39 | $18-$28 | $18-$28 | $18-$28 | $16-$24 |
| 5. Field Cubing and Hauling d/ | $34-$68 | $34-$52 | $25-$37 | $25-$37 | $22-$31 |

a/ Costs include an $8/acre charge for use of a mobile field incinerator but exclude any expenses which may be required for residue utilization or disposal.

b/ Due to a lack of data, no range in costs were calculated. Only a custom rate of $10/ton for chopping, blowing, and hauling, and $8/acre for field sanitation were used.

c/ Projecting a range in baling and hauling costs of $6 to $12/ton with no swathing required.

d/ Projecting a range in cubing and hauling costs of $10 to $17/ton.

Source: Conklin, Frank S. and R. Carlyle Bradshaw, *An Economic Evaluation of Suggested On-Farm Alternatives to Open Field Burning for Willamette Valley Grass Seed Producers*, Oregon Agricultural Experiment Station Special Report (in press), Oregon State University, Corvallis.

## II. THE POLLUTION PRODUCTION FUNCTION

### A. The Importance of the Pollution Production Function

An important fraction of our continuing research effort has been devoted to the specification and estimation of the pollution production functions associated with open burning of agricultural fields in the Willamette Valley. Open field burning produces smoke that, depending upon atmospheric conditions, is transported to various points in the Valley or out of the Valley. To economists, the problem of accounting for the impact of this burning process on visibility appeared analogous to the problem in economics of estimating what is called a 'production function'. A production function is an analytical concept that asserts the existence of a set of fixed relationships between an output or set of outputs on the one hand and a set of inputs on the other. For economists, the problem of estimating production functions has been confined to providing adequate specification of the reasonable independent variables in the process and ascertaining, a priori, what mathematical form this production process might reasonably take. Economists have had some success in the empirical estimation of particular production functions.*

In our research, a pollution production function has been regarded as an analytical concept that postulates the existence of a set of stable relationships between daylight visibility in particular locations in the Valley under varying present and recently past meteorological conditions and recently past emission rates throughout the Valley. Meteorological conditions determine how the atmosphere transports emissions from field burning from one location to another in the Valley, and acres burned determine emission rates and atmospheric loading in different zones of the Valley. Meteorologists have described the Willamette Valley as a box with a movable lid and a set of ventilating windows.** Alternative specifications of relevant meteorological variables consistent with that model have been explored in our research. Empirical estimation has concentrated on functions with minimum daylight visibility at Eugene and Salem as the dependent variable and acres-burned among the independent variables.

There are two reasons why our research initially and continuously has focused quite intensively on estimation of the pollution production function. First, research success promised to provide immediately valuable information for the Oregon Department of Environmental Quality in the development of its field burning control policy to minimize the harmful effects

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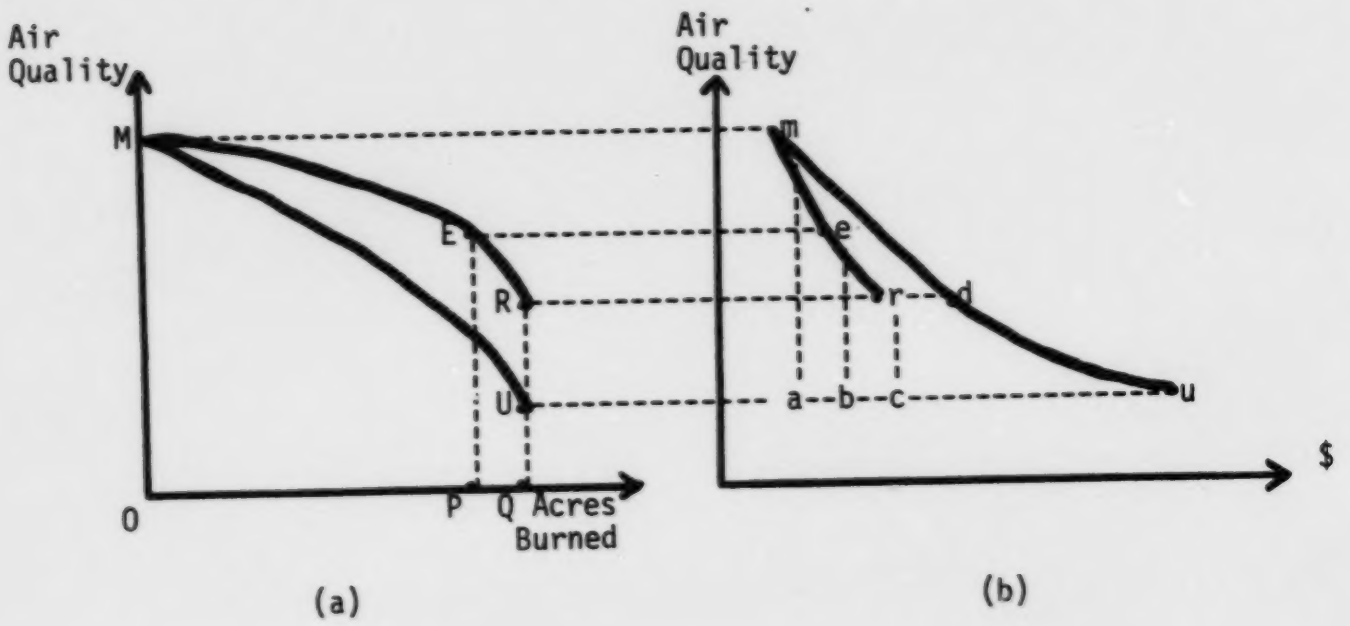
* For example, see Marc Nerlove, Estimation and Identification of Cobb-Douglas Production Functions, Chicago: Rand McNally, 1965.

** Olsson, Lars E. and Wesley L. Tuft, A Study of the Natural Ventilation of the Columbia-Willamette Valleys, Technical Report No. 70-6, Department of Atmospheric Sciences, Oregon State University, Corvallis, Oregon, June 1970, pp. 133-137.

associated with smoke produced by open burning of agricultural fields. For precisely this reason, Bruce Snyder, the meteorologist with the DEQ, and faculty members of the Department of Atmospheric Sciences at Oregon State University have generously supplied data and advice throughout our research. Second, and most important given our research objectives, measurements of the benefits to be obtained from various field burning control policies is impossible without the pollution production function. This is the case because the pollution production function is a major determinant of the marginal valuation schedule of air quality improvements from field burning control.

Assuming known pollution production functions and a known (constant or declining) marginal value schedule for successive improvements in air quality, the above point may be established with the aid of Figure II.1, where an (unspecified) index of air quality is measured along the vertical axis, while acres-burned and the marginal value of successive air quality improvements are measured horizontally in panels (a) and (b), respectively. In panel (a), curves MR and MU illustrate hypothetical relationships derived from pollution production functions estimated under conditions where burning is and is not regulated according to prevailing and forecast air quality and meteorological conditions. In panel (b), the marginal valuations of successive improvements in air quality are plotted with and without well-regulated burning, and mr and mu are associated with MR and MU, respectively.

Figure II.1



Following standard benefit measurement techniques, the gross benefits of field burning regulated according to prevailing and forecast air quality and meteorological conditions would be measured by the area rcud with no reduction in total acres burned. Furthermore, since the benefits rcud are obtainable with no reduction in total acres burned, the maximum benefits from a complete ban of field burning would be measured by the area macr , whereas regulated burning couples with an acres-burned reduction equal to PQ would result in benefits measured by berc. Consequently, correct estimation of the benefits derived from all field burning control programs would be quite impossible without the pollution production function.

## B. The Model

The basic hypothesis of our model is that daylight visibility is a function of prevailing meteorological conditions and the load of contaminants placed in the atmosphere by pollutors. However, since atmospheric load at any given location and time is itself a function of present and recently past contaminant emission rates at that and other locations, a more complete and accurate statement of the hypothesis would be as follows. Daylight visibility at a given location is a function of (1) the present and recently past air-contaminant emission rates at that and other locations and (2) the present and recently past capacity of the atmosphere to dilute and transport its contaminants from one location to another.

Operational specification of this hypothesis is no simple task. Contaminants are emitted at non-uniform rates from numerous sources for which data are limited or not available, while atmospheric dispersion and transportation processes are complex and meteorological data above the surface are obtained only twice per day for the Willamette Valley. Consequently, for statistical testing, daily variations in minimum daily visibility are hypothesized to be "explained" by variations in different sets of independent variables reflecting air-contaminant emission rates and the atmospheric transportation process. Alternative specifications of present and past emission rates (via various proxy variables) and the capacity of the atmosphere to disperse and transport contaminants require discussion, however, prior to the presentation of our results.

Although atmospheric load is the result of emissions from numerous sources, the primary concern here is with the atmospheric loading effect of field burning on visibility. Therefore, the research is designed to test a strong hypothesis about the visibility-field burning relationship. This is accomplished by employing (a) a theoretically reasonable data configuration, (b) an explicit hypothesis concerning emissions from other than field burning sources for which data are not now systematically collected, and (c) proxy variables for daily field burning emission rates and background load before fields are burned on any given day. This procedure means that field burning is treated as an important marginal contributor to atmospheric loading. Variations in field burning emission rates together with variations in the background load and emissions from sources other than field burning are regarded as jointly determining variations in atmospheric loading.

Regarding the selected data configuration, data are excluded for days on which field burning was less than 100 acres in total. Although the decision to confine consideration to 100-plus acre burning days is admittedly arbitrary, it does not appear unreasonable.

Unfortunately, despite the importance of automobiles, pulp mills, etc. as sources of air contaminants, no daily data are systematically collected on emissions from these sources. Without these data, it is hypothesized that daily emissions from these sources are regular and stable and that, therefore, they can be treated analytically as constant.

Regarding field-burning emission rates, the number of acres burned throughout, or in particular zones of, the Willamette Valley serve as a proxy for field-burning emissions. Data are available on the acreage of total field burning permits issued daily by fire district in 1969 and 1970, and these data can be aggregated to reflect the burning in various zones of the Valley or in the Valley as a whole. In contrast, however, there is no need to identify or measure the sources of the varying daily initial background load existing prior to each day's field burning. This is because background load is appropriately treated as a predetermined variable (i.e., determined by emissions from many sources on the previous day(s) as well as past meteorological conditions). Here, visibility at 7 a.m. at the location under study provides the proxy for background load.

Turning next to the capacity of the atmosphere to dilute and transport its load, the variables that seemed most appropriate were mid-afternoon inversion height, atmospheric stability, wind speed, and wind direction. Although we had access to the full range of meteorological data, we deliberately did not seek to use it all. In our view, whatever model we hypothesized and tested, it was essential to minimize colinearity among the independent variables. For this reason other variables generally associated with atmospheric stability (such as surface temperature, relative humidity counts, etc.) were excluded.

Regarding the empirical data, several problems deserve note. The data on inversion height were measured in millibars of pressure and used in this form. Hence, the relationship between inversion height and minimum daylight visibility was predicted to be negative: the higher the measured inversion pressure, other things equal, the lower would be visibility. We recognize one shortcoming of the analysis in that no consideration was given to the thickness of the inversion layer.

Utilization of a stability measure that was theoretically plausible and empirically meaningful was difficult. Daily data are available on air temperature changes between the surface and 900 millibars, 800 and 900 millibars, and 700 and 800 millibars. These air temperature change data are measures of stability. For purposes of model specification, the problem was to select a particular band, a combination, or use all three bands as stability proxies. The appropriate measure or measures of stability should reasonably be confined to the mixing layer. After considering the direction of the prevailing winds and the heighth of the Cascade Range, it was decided to use the air temperature change data in the surface to 900 millibar range as the measure of stability.

The character of the physical problem being considered suggested that wind direction must play a prominent role in the analysis. The problem was how to treat it. The method of measuring wind direction makes the data difficult to use if one attempts to employ continuous variables. Two schemes were considered which relied on arbitrary designation of winds from the north, south, east, and west. One of these schemes employed a weighting arrangement for simultaneously taking account of both wind speed and direction. Given the measurement and data problems and given the predicted strong relationship between wind direction and low visibility in Eugene and Salem, it was decided to take wind direction into account by a data sorting technique. That is, winds from the north could potentially contribute to deterioration of the visibility at Eugene and Salem. On the other hand, given the locations of Eugene and Salem, winds from the south should improve visibility. Therefore, it was decided to investigate (a) visibility in Eugene only on days with winds from the north and (b) visibility at Salem, first, on days with north winds and, second, on days with southerly winds.

Reference has been made to the "relevant wind". Wind measurements are available at both the surface and at 850 millibars. Meaningful analysis required that a decision be made as to which measure to use. The relevant data are clearly those that apply to the mixing layer. If the inversion height was lower than 850 millibars (i.e., more than 850 millibars of pressure) the only relevant wind data on speed and direction was provided by the surface measurements. On the other hand, if the inversion pressure was above 850 millibars it seemed reasonable that measurements of wind direction and speed at 850 millibars would be utilized in the analysis. We adopted this as a selection rule for determining which measurements of wind speed and direction were considered for each day. Furthermore, in the model variants where wind speed was treated as an independent variable, the data were expressed in knots per hour.

Specification of the empirical data which could reasonably serve as proxies for the theoretical determinants of minimum daylight visibility was but one portion of the model specification problem. Completion of this problem required specification of a theoretically plausible mathematical form. Adopting the principle of "Occam's Razor" as a guide, first, we tested a linear version of the model. Next we examined a form in which the independent variables were treated as multiplicative and the function as exponential. This form was plausible on physical grounds as well as having achieved noteworthy success when adopted for estimating economic production functions. For statistical purposes, the multiplicative-exponential form meant estimation of equations linear in the logarithms of all variables.

C. Statistical Results*

Five variants of our basic model have been tested for Eugene and Salem on 1969, 1970, and pooled 1969-70 data for days on which at least 100 acres burned. These variants differ from one another according to their respective specifications of the independent variables reflecting atmospheric capacity to dilute and transport load. The model variants, expressed in general form, are as follows:

$$\text{I.} \qquad V = V_I\ (A, V_{7A})$$

$$\text{II.} \qquad V = V_{II}\ (A, V_{7A}, I_{4P})$$

$$\text{III.} \qquad V = V_{III}\ (A, V_{7A}, I_{4P}, W_S)$$

$$\text{IV.} \qquad V = V_{IV}\ (A, V_{7A}, I_{4P}, S)$$

$$\text{V.} \qquad V = V_V\ (A, V_{7A}, I_{4P}, W_S, S)$$

where V = minimum afternoon daylight visibility at the Eugene or Salem airport, A = total acres burned in the Willamette or total acres burned north and/or south of the Salem airport according to the relevant wind direction at 4 p.m., $V_{7A}$ = visibility at 7 a.m. at the Eugene or Salem airport, $I_{4P}$ = inversion height at 4 p.m., $W_S$ = relevant wind speed at 4 p.m., and S = atmospheric stability at 4 p.m.

As mentioned above, the mathematical forms assumed for purposes of analysis were the linear and log - log forms. Interestingly, the estimated relationships and the statistical significance of the regression coefficients did not vary dramatically between functional forms. However, for all models the fits in terms of both $R^2$ and the F-statistic were clearly better when the log - log form was employed. Consequently, this paper reports regression results for models in log - log form only.

The multiple regression results obtained for each model variant, as well as the beta coefficients of each regression coefficient, are reported in Tables II.1 through II.10. (Since the size of estimated regression coefficients varies with the units in which each independent variable is stated, regression coefficients do not indicate the importance of the independent variables in statistically explaining variations in

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*The results reported in this section extend and supersede those presented in our paper "Field Burning and Visibility Reduction in the Willamette Valley: A Pollution Production Function", which was given at the Eighth Annual Meeting, Pacific Northwest International Section, Air Pollution Control Association, Spokane, Washington, November 18, 1970.

Table II.1

Regression Results: Eugene Under Northerly Wind Conditions, 1969.

| | I | II | III | IV | V |
|---|---|---|---|---|---|
| Regression Coefficients, Etc. | | | | | |
| Constant | 2.664 | 15.472 | 16.044 | 14.800 | 15.052 |
| Total acres burned | -0.629[a] (5.262) | -0.570[a] (5.081) | -0.561[a] (5.017) | -0.591[a] (4.963) | -0.593[a] (5.095) |
| Visibility at 7 AM | 0.261 (1.162) | 0.261 (1.270) | 0.271[d] (1.331) | 0.265 (1.273) | 0.282[d] (1.383) |
| Inversion height | | -4.445[b] (2.310) | -4.736[b] (2.457) | -4.474[b] (2.289) | -4.865[b] (2.518) |
| Windspeed | | | 0.273 (1.140) | | 0.347[d] (1.384) |
| Atmospheric stability | | | | 0.425 (0.602) | 0.721 (0.998) |
| Daily observations | 25 | 25 | 25 | 25 | 25 |
| $\bar{R}^2$ | 0.545 | 0.619 | 0.626 | 0.608 | 0.625 |
| F-statistic | 15.376[a] | 14.050[a] | 11.013[a] | 10.308[a] | 9.007[a] |
| Beta Coefficients | | | | | |
| Total acres burned | 0.729 | 0.660 | 0.650 | 0.685 | 0.687 |
| Visibility at 7 AM | 0.161 | 0.161 | 0.167 | 0.164 | 0.174 |
| Inversion height | | 0.299 | 0.318 | 0.301 | 0.327 |
| Windspeed | | | 0.144 | | 0.183 |
| Atmospheric stability | | | | 0.081 | 0.137 |

Note: Figures in parentheses are t-statistics.

[a] Significant at the 1 percent level.
[b] Significant at the 5 percent level.
[c] Significant at the 10 percent level.
[d] Significant at the 20 percent level.

Table II.2

Regression Results: Eugene Under Northerly Wind Conditions, 1970.

| | I | II | III | IV | V |
|---|---|---|---|---|---|
| Regression Coefficients, Etc. | | | | | |
| Constant | 2.084 | 5.259 | 5.268 | 6.988 | 6.918 |
| Total acres burned | -0.486[a] (2.842) | -0.0464[b] (2.607) | -0.474[b] (2.496) | -0.472[b] (2.575) | -0.480[b] (2.452) |
| Visibility at 7 AM | 0.400[b] (2.514) | 0.381[b] (2.308) | 0.392[b] (2.201) | 0.359[b] (2.030) | 0.368[c] (1.912) |
| Inversion height | | -1.101 (0.597) | -1.072 (0.564) | -1.361 (0.686) | -1.328 (0.645) |
| Wind speed | | | -0.070 (0.206) | | -0.053 (0.150) |
| Atmospheric stability | | | | -0.442 (0.432) | -0.423 (0.397) |
| Daily observations | 21 | 21 | 21 | 21 | 21 |
| $\bar{R}^2$ | 0.656 | 0.644 | 0.625 | 0.628 | 0.605 |
| F-statistic | 18.564[a] | 12.052[a] | 8.541[a] | 8.654[a] | 6.504[a] |
| Beta Coefficients | | | | | |
| Total acres burned | 0.485 | 0.463 | 0.473 | 0.471 | 0.479 |
| Visibility at 7 AM | 0.429 | 0.409 | 0.420 | 0.385 | 0.395 |
| Inversion height | | 0.090 | 0.088 | 0.112 | 0.109 |
| Wind speed | | | 0.035 | | 0.026 |
| Atmospheric stability | | | | 0.065 | 0.063 |

Note: Figures in parentheses are t-statistics.

[a] Significant at the 1 percent level.
[b] Significant at the 5 percent level.
[c] Significant at the 10 percent level.
[d] Significant at the 20 percent level.

Table II.3

Regression Results: Eugene Under Northerly Wind Conditions, 1969.

| | I | II | III | IV | V |
|---|---|---|---|---|---|
| **Regression Coefficients, Etc.** | | | | | |
| Constant | 2.952 | 16.824 | 17.786 | 14.989 | 15.640 |
| North acres burned | -0.411[d] (1.427) | -0.321 (1.197) | -0.294 (1.089) | -0.256 (0.926) | -0.197 (0.720) |
| South acres burned | -0.324[c] (1.985) | -0.344[b] (2.287) | -0.335[b] (2.229) | -0.427[b] (2.473) | -0.444[b] (2.626) |
| Visibility at 7 AM | 0.089 (0.335) | 0.140 (0.571) | 0.153 (0.626) | 0.163 (0.664) | 0.190 (0.786) |
| Inversion height | | -4.827[c] (2.066) | -5.281[b] (2.220) | -4.753[c] (2.031) | -5.333[b] (2.290) |
| Wind speed | | | 0.276 (1.004) | | 0.367[d] (1.323) |
| Atmospheric stability | | | | 0.848 (0.983) | 1.139[d] (1.307) |
| Daily observations | 22 | 22 | 22 | 22 | 22 |
| $\bar{R}^2$ | 0.430 | 0.517 | 0.517 | 0.516 | 0.538 |
| F-statistic | 6.264[a] | 6.618[a] | 5.495[a] | 5.477[a] | 5.070[a] |
| **Beta Coefficients** | | | | | |
| North acres burned | 0.329 | 0.258 | 0.236 | 0.205 | 0.158 |
| South acres burned | 0.438 | 0.466 | 0.453 | 0.578 | 0.601 |
| Visibility at 7 AM | 0.059 | 0.093 | 0.102 | 0.108 | 0.126 |
| Inversion height | | 0.318 | 0.348 | 0.313 | 0.351 |
| Wind speed | | | 0.157 | | 0.209 |
| Atmospheric stability | | | | 0.174 | 0.209 |

Note: Figures in parentheses are t-statistics.

[a]Significant at the 1 percent level.
[b]Significant at the 5 percent level.
[c]Significant at the 10 percent level.
[d]Significant at the 20 percent level.

Table II.4

Regression Results: Eugene Under Northerly Wind Conditions, 1970.

| | I | II | III | IV | V |
|---|---|---|---|---|---|
| Regression Coefficients, Etc. | | | | | |
| Constant | 1.768 | 8.252 | 8.348 | 9.324 | 9.607 |
| North acres burned | -0.236<br>(1.257) | -0.255[d]<br>(1.353 | -0.255<br>(1.305) | -0.252<br>(1.286) | -0.252<br>(1.236) |
| South acres burned | -0.229[c]<br>(2.013) | -0.210[c]<br>(1.821) | -0.209[c]<br>(1.745) | -0.208[c]<br>(1.739) | -0.207[d]<br>(1.655) |
| Visibility at 7 AM | 0.453[b]<br>(2.574) | 0.432[b]<br>(2.445) | 0.425[b]<br>(2.168) | 0.424[b]<br>(2.267) | 0.412[c]<br>(1.958) |
| Inversion height | | -2.201<br>(1.018) | -2.245<br>(0.985) | -2.401<br>(0.994) | -2.491<br>(0.963) |
| Wind speed | | | 0.039<br>(0.109) | | 0.057<br>(0.148) |
| Atmospheric stability | | | | 0.238<br>(0.220) | -0.270<br>(0.236) |
| Daily observations | 19 | 19 | 19 | 19 | 19 |
| $\bar{R}^2$ | 0.558 | 0.557 | 0.520 | 0.521 | 0.480 |
| F-statistic | 9.556[a] | 7.443[a] | 5.537[a] | 5.560[a] | 4.288[b] |
| Beta Coefficients | | | | | |
| North acres burned | 0.194 | 0.210 | 0.210 | 0.207 | 0.207 |
| South acres burned | 0.389 | 0.357 | 0.355 | 0.353 | 0.352 |
| Visibility at 7 AM | 0.503 | 0.480 | 0.472 | 0.471 | 0.458 |
| Inversion height | | 0.163 | 0.166 | 0.178 | 0.184 |
| Wind speed | | | 0.019 | | 0.028 |
| Atmospheric stability | | | | 0.038 | 0.043 |

Note: Figures in parentheses are t-statistics

[a] Significant at the 1 percent level.
[b] Significant at the 5 percent level.
[c] Significant at the 10 percent level.
[d] Significant at the 20 percent level.

Table II.5

Regression Results: Salem Under Northerly Wind Conditions, 1969.

| | I | II | III | IV | V |
|---|---|---|---|---|---|
| Regression Coefficients, Etc. | | | | | |
| Constant | 1.697 | 15.578 | 15.936 | 15.431 | 15.704 |
| North acres burned | -0.297[c] | -0.225[d] | -0.217[d] | -0.229[d] | -0.226[d] |
| | (1.755) | (1.434) | (1.357) | (1.405) | (1.358) |
| Visibility at 7 AM | 0.147 | 0.123 | 0.088 | 0.121 | 0.075 |
| | (0.455) | (0.419) | (0.284) | (0.401) | (0.235) |
| Inversion height | | -4.809[b] | -4.962[b] | -4.828[b] | -5.036[b] |
| | | (2.385) | (2.384) | (2.334) | (2.349) |
| Wind speed | | | 0.125 | | 0.152 |
| | | | (0.465) | | (0.527) |
| Atmospheric stability | | | | 0.113 | 0.238 |
| | | | | (0.155) | (0.306) |
| Daily observations | 25 | 25 | 25 | 25 | 25 |
| $\bar{R}^2$ | 0.067 | 0.231 | 0.169 | 0.160 | 0.164 |
| F-statistic | 18.704[a] | 3.408[b] | 2.515 | 2.444 | 1.940 |
| Beta Coefficients | | | | | |
| North acres burned | 0.352 | 0.267 | 0.257 | 0.272 | 0.268 |
| Visibility at 7 AM | 0.091 | 0.076 | 0.055 | 0.075 | 0.047 |
| Inversion height | | 0.436 | 0.450 | 0.438 | 0.457 |
| Wind speed | | | 0.089 | | 0.108 |
| Atmospheric stability | | | | 0.029 | 0.061 |

Note: Figures in parentheses are t-statistics

[a] Significant at the 1 percent level.
[b] Significant at the 5 percent level.
[c] Significant at the 10 percent level.
[d] Significant at the 20 percent level.

Table II.6

Regression Results: Salem Under Northerly Wind Conditions, 1970.

| | I | II | III | IV | V |
|---|---|---|---|---|---|
| Regression Coefficients, Etc. | | | | | |
| Constant | 0.131 | -1.111 | 1.183 | -0.816 | 1.254 |
| North acres burned | -0.019<br>(0.132) | -0.023<br>(0.150) | 0.039<br>(0.253) | -0.023<br>(0.145) | 0.039<br>(0.245) |
| Visibility at 7 AM | 0.770[a]<br>(5.718) | 0.791[a]<br>(4.647) | 0.563[b]<br>(2.588) | 0.792[a]<br>(4.510) | 0.563[c]<br>(2.504) |
| Inversion height | | 0.418<br>(0.214) | -0.520<br>(0.265) | 0.379<br>(0.183) | -0.529<br>(0.265) |
| Wind speed | | | 0.544[d]<br>(1.587) | | 0.543[d]<br>(1.534) |
| Atmospheric stability | | | | -0.086<br>(0.089) | -0.021<br>(0.023) |
| Daily observations | 21 | 21 | 21 | 21 | 21 |
| $\bar{R}^2$ | 0.606 | 0.584 | 0.617 | 0.557 | 0.592 |
| F-statistic | 16.350[a] | 10.337[a] | 9.075[a] | 7.303[a] | 6.807[a] |
| Beta Coefficients | | | | | |
| North acres burned | 0.018 | 0.022 | 0.037 | 0.022 | 0.037 |
| Visibility at 7 AM | 0.803 | 0.825 | 0.587 | 0.826 | 0.587 |
| Inversion height | | 0.038 | 0.047 | 0.034 | 0.048 |
| Wind speed | | | 0.302 | | 0.301 |
| Atmospheric stability | | | | 0.013 | 0.003 |

Note: Figures in parentheses are t-statistics

[a] Significant at the 1 percent level.
[b] Significant at the 5 percent level.
[c] Significant at the 10 percent level.
[d] Significant at the 20 percent level.

Table II.7

Regression Results: Eugene Under Northerly Wind Conditions, 1969-70.

| | I | II | III | IV | V |
|---|---|---|---|---|---|
| Regression Coefficients, Etc. | | | | | |
| Constant | 2.552 | 10.847 | 11.100 | 10.394 | 10.697 |
| Total acres burned | -0.607[a] (6.663) | -0.563[a] (6.291) | -0.549[a] (6.054) | -0.569[a] (6.280) | -0.554[a] (6.028) |
| Visibility at 7 AM | 0.315[b] (2.541) | 0.283[b] (2.2362) | 0.258[b] (2.121) | 0.280[b] (2.319) | 0.257[b] (2.092) |
| Inversion height | | -2.870[b] (2.187) | -3.022[b] (2.291) | -2.880[b] (2.180) | -3.024[b] (2.272) |
| Wind speed | | | 0.181 (1.034) | | 0.172 (0.971) |
| Atmospheric stability | | | | 0.252 (0.644) | 0.218 (0.553) |
| Daily observations | 46 | 46 | 46 | 46 | 46 |
| $\bar{R}^2$ | 0.600 | 0.633 | 0.632 | 0.627 | 0.626 |
| F-statistic | 34.718[a] | 26.776[a] | 20.383[a] | 19.906[a] | 16.092[a] |
| Beta Coefficients | | | | | |
| Total acres burned | 0.665 | 0.617 | 0.602 | 0.624 | 0.607 |
| Visibility at 7 AM | 0.254 | 0.228 | 0.208 | 0.226 | 0.207 |
| Inversion height | | 0.207 | 0.218 | 0.207 | 0.218 |
| Wind speed | | | 0.097 | | 0.093 |
| Atmospheric stability | | | | 0.059 | 0.051 |

Note: Figures in parentheses are t-statistics

[a] Significant at the 1 percent level.
[b] Significant at the 5 percent level.
[c] Significant at the 10 percent level.
[d] Significant at the 20 percent level.

Table II.8

Regression Results: Eugene Under Northerly Wind Conditions, 1969-70.

| | I | II | III | IV | V |
|---|---|---|---|---|---|
| Regression Coefficients, Etc. | | | | | |
| Constant | 2.421 | 13.491 | 14.214 | 12.802 | 13.572 |
| North acres burned | -0.293[c] (1.977) | -0.299[b] (2.154) | -0.300[b] (2.170) | -0.302[b] (2.150) | -0.301[b] (2.162) |
| South acres burned | -0.332[a] (3.958) | -0.314[a] (3.978) | -0.294[a] (3.682) | -0.316[a] (3.966) | -0.297[a] (3.670) |
| Visibility at 7 AM | 0.277[c] (1.972) | 0.254[c] (1.928) | 0.233[c] (1.763) | 0.255[c] (1.915) | 0.234[c] (1.752) |
| Inversion height | | -3.780[b] (2.486) | -4.115[b] (2.681) | -3.722[b] (2.422) | -4.055[b] (2.610) |
| Wind speed | | | 0.240 (1.223) | | 0.234 (1.182) |
| Atmospheric stability | | | | 0.265 (0.620) | 0.241 (0.566) |
| Daily observations | 41 | 41 | 41 | 41 | 41 |
| $\bar{R}^2$ | 0.525 | 0.583 | 0.589 | 0.576 | 0.581 |
| F-statistic | 15.741[a] | 15.004[a] | 12.467[a] | 11.875[a] | 10.241[a] |
| Beta Coefficient | | | | | |
| North acres burned | 0.234 | 0.238 | 0.239 | 0.241 | 0.240 |
| South acres burned | 0.507 | 0.480 | 0.446 | 0.483 | 0.454 |
| Visibility at 7 AM | 0.234 | 0.215 | 0.197 | 0.216 | 0.198 |
| Inversion height | | 0.256 | 0.279 | 0.252 | 0.275 |
| Wind speed | | | 0.131 | | 0.128 |
| Atmospheric stability | | | | 0.064 | 0.058 |

Note: Figures in parentheses are t-statistics

[a] Significant at the 1 percent level.
[b] Significant at the 5 percent level.
[c] Significant at the 10 percent level.
[d] Significant at the 20 percent level.

Table II.9

Regression Results: Salem Under Northerly wind Conditions, 1969-70.

| | I | II | III | IV | V |
|---|---|---|---|---|---|
| Regression Coefficients, Etc. | | | | | |
| Constant | 0.795 | 10.596 | 11.522 | 10.559 | 11.484 |
| North acres burned | -0.172[d] (1.451) | -0.138 (1.215) | -0.119 (1.044) | -0.138 (1.202) | -0.115 (1.034) |
| Visibility at 7 AM | 0.599[a] (3.953) | 0.478[a] (3.120) | 0.383[b] (2.227) | 0.477[a] (3.035) | 0.381[b] (2.169) |
| Inversion height | | -3.333[b] (2.330) | -3.708[b] (2.544) | -3.340[b] (2.302) | -3.715[b] (2.513) |
| Wind speed | | | 0.243 (1.197) | | 0.243 (1.183) |
| Atmospheric stability | | | | 0.030 (0.070) | 0.031 (0.072) |
| Daily observations | 46 | 46 | 46 | 46 | 46 |
| $\bar{R}^2$ | 0.273 | 0.341 | 0.347 | 0.325 | 0.331 |
| F-statistic | 9.435[a] | 8.747[a] | 6.986[a] | 6.406[a] | 5.454[a] |
| Beta Coefficients | | | | | |
| North acres burned | 0.186 | 0.149 | 0.129 | 0.149 | 0.124 |
| Visibility at 7 AM | 0.504 | 0.403 | 0.323 | 0.402 | 0.321 |
| Inversion height | | 0.303 | 0.337 | 0.304 | 0.338 |
| Wind speed | | | 0.164 | | 0.164 |
| Atmospheric stability | | | | 0.009 | 0.009 |

Note: Figures in parentheses are t-statistics

[a] Significant at the 1 percent level.
[b] Significant at the 5 percent level.
[c] Significant at the 10 percent level.
[d] Significant at the 20 percent level.

Table II.10

Regression Results: Salem Under Southerly Wind Conditions, 1969-70.

| | I | II | III | IV | V |
|---|---|---|---|---|---|
| Regression Coefficients, Etc. | | | | | |
| Constant | -0.842 | 22.647 | 21.979 | 27.131 | 28.000 |
| South acres burned | -0.113<br>(1.219) | -0.273[a]<br>(3.971) | -0.274[a]<br>(3.837 | -0.266[a]<br>(4.055) | -0.265[a]<br>(3.856) |
| Visibility at 7 AM | 0.433[c]<br>(1.764) | 0.187<br>(1.128) | 0.179<br>(1.028) | 0.165<br>(1.035) | 0.169<br>(1.010) |
| Inversion height | | -7.218[a]<br>(4.631) | -7.018[a]<br>(4.137) | -8.546[a]<br>(4.934) | -8.805[a]<br>(4.243) |
| Wind speed | | | 0.091<br>(0.389) | | -0.064<br>(0.255) |
| Atmospheric stability | | | | -0.321<br>(1.035) | -0.064<br>(1.390) |
| Daily observations | 17 | 17 | 17 | 17 | 17 |
| $\bar{R}^2$ | 0.107 | 0.663 | 0.640 | 0.696 | 0.671 |
| F-statistic | 1.965 | 10.616[a] | 7.437[a] | 9.326[a] | 6.840[a] |
| Beta Coefficients | | | | | |
| South acres burned | 0.284 | 0.687 | 0.689 | 0.669 | 0.667 |
| Visibility at 7 AM | 0.425 | 0.187 | 0.176 | 0.162 | 0.137 |
| Inversion height | | 0.849 | 0.825 | 1.005 | 1.035 |
| Wind speed | | | 0.067 | | 0.047 |
| Atmospheric stability | | | | 0.266 | 0.290 |

Note: Figures in parentheses are t-statistics

[a] Significant at the 1 percent level.
[b] Significant at the 5 percent level.
[c] Significant at the 10 percent level.
[d] Significant at the 20 percent level.

minimum afternoon daylight visibility in Eugene or Salem. Such information can be deduced from beta coefficients, however. Beta coefficients convert regression coefficients into standardized units. Here, the beta coefficients measure the effect on minimum daylight visibility of typical changes in the independent variables in terms of sample standard deviations.) Tables II.1 through II.6 present regression results for Eugene and Salem with winds from the north in 1969 and 1970, while Tables II.7 to II.9 report our regression findings when 1969 and 1970 data sets are combined. Table II.10 shows the results found for Salem under southerly wind conditions during 1969 and 1970.

Viewed most broadly, the regression results reported in Tables II.1 through II.10 are noteworthy on two counts. First, the results support the predictions of our simple atmospheric models reasonably well. Second, the most important variations between the 1969 and 1970 regression results for all variants of the basic model apparently derive from the new burning regulations applied for the first time in 1970 by the Oregon Department of Environmental Quality, Air Quality Control Division. The evidence to support these judgments follows.

Temporarily ignoring changes in the size, statistical significance, and relative importance of independent variables between the 1969 and 1970 burning seasons, all statistically significant, and most statistically insignificant, variables have their theoretically anticipated signs and thereby support the simple atmospheric models postulated here. Among the typically statistically significant variables, minimum daylight visibility varies inversely with relevant (i.e., total, north, and/or south) acres burned and directly with visibility before burning and mid-afternoon inversion height (recall that inversion heights are measured here in millibars of pressure), while the statistically insignificant wind speed and atmospheric stability variables generally have the positive signs that theoretical reasoning predicts.

Although the size of the statistically insignificant regression coefficients varies substantially among model variants, alternative specifications of the atmospheric load transport and dilution mechanism hardly change the regression coefficients for relevant acres burned, visibility before burning, or inversion height. In particular, the stability of the regression coefficients is important because the specification of the log - log functional form means that the estimated coefficient provides a direct measure of the elasticity of minimum visibility with respect to the various statistically significant independent variables.* For example, the estimated total-acres-burned coefficient in Table II.1 indicates that a 10 percent change (above or below the 1969 average) would have meant an opposite 6 percent change in Eugene minimum visibility in 1969, holding all other variables constant.

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* The elasticity of a dependent variable with respect to some independent variable indicates the responsiveness of the former to changes in the latter and is measured by the percentage change in the dependent variable divided by the percentage change in the independent variable, all other independent variables being held constant.

Furthermore, with the notable exception of Salem under northerly wind conditions in 1969 and 1969-70 (see Tables 5 and 9), it is encouraging to note that the most important independent variables in terms of their respective beta coefficients are the generally statistically significant acres burned, visibility before burning, and inversion height variables. Since statistically significant regression coefficients are not always associated with relatively large beta coefficients, this evidence suggests that model variants II and III are superior to variants I, IV, and V in terms of statistical explanatory power as well as in terms of goodness of fit as indicated by their respective $\bar{R}^2$ and F-statistics. Consequently, our regression results provide support for the hypothesis that daylight visibility in the Willamette Valley is a function of the load of contaminants placed in the atmosphere by pollutors and the prevailing meteorological conditions.

For Eugene, when winds were from the north, a statistically significant relationship obtained (see Tables II.1,2,3,4,7 and 8) between variations in minimum daylight visibility and relevant acres burned, as well as other independent variables reflecting air-contaminant emission rates and the atmospheric transportation process. These findings clearly establish the impact of field burning smoke on visibility at Eugene. Furthermore, these findings support the fundamental correctness of the 1970 and 1971 Department of Environmental Quality field burning program and schedule to reduce deterioration of visibility in Eugene by curtailing acres burned under north winds. Also, Tables II.3,4 and 8 corroborate the DEQ finding that smoke from North Valley burning is an important determinant of visibility in Eugene.*

Finally, for Salem, under southerly wind conditions, a statistically important relationship obtained between minimum daylight visibility and acres burned in the South Valley (see Table II.10). Of course, this finding demonstrates the conflict inherent in the 1970 and 1971 DEQ field burning program to minimize visibility losses in Eugene by reducing South Valley acres burned under north winds while allowing large South Valley acreages to be burned with south winds. Burning South Valley acreage under northerly wind conditions reduces visibility in Eugene, while burning such acreage with south winds lowers visibility in Salem. Such conflicts are necessarily involved in smoke management programs which attempt to minimize the harmful effects of field-burning smoke by attempting to control the distribution rather than the volume of the smoke.

We turn next to the rather large changes in the size and statistical significance in the regression coefficients estimated from 1969 and 1970 data, respectively. A comparison of the regression coefficients for relevant acres burned, visibility before burning, and inversion height in Tables II.1 and 2,3,4,5, and 6 indicates (1) declines in the size, statistical significance, and relative importance (measured by beta coefficients) of the relevant acres burned and mid-afternoon inversion height variables and (2) an increase in the size, statistical significance, and relative

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*Department of Environmental Quality, Air Quality Control Division, "Field Burning in the Willamette Valley, 1970," staff report dated April 8, 1971, p. 14.

importance of the visibility-before-burning variable. Although such significant (i.e., year-to-year changes in estimated regression coefficients larger than their standard errors in either year) and systematic changes would normally suggest an incorrect specification of fundamental functional relationships, in this particular instance such an inference would be erroneous. This is the case because field burning regulations, schedule, and actual burning in 1970 differed substantially from earlier years, and the observed differences between our 1969 and 1970 findings under northerly wind conditions simply reflect the operational impact of the 1970 burning program.

The 1970 burning schedule had four new features designed to keep "smoke away from the Eugene-Springfield area while having a minimal effect on Salem.

(1) Heavy burning (up to 15,500 acres per day) to be conducted in Benton, Lane and Linn Counties under persistent southwest winds, with little or no burning the the North Valley.

(2) Moderate burning (about 2,000 acres per day) to be conducted in the North Valley under northwest winds, with little or no burning in Benton, Lane, and Linn Counties.

(3) Buffer zones, called priority areas, to be established around major airports, cities of 10,000 or more and major highways in which burning would be done under conditions conducive to keeping direct smoke out of the area of concern...

(4) Quotas to be established for allowable daily burning acreage in each fire district, with the quota based on grass acreage in the Districts and the expected number of days of acceptable wind direction."*

With stringent controls of burning in priority areas, the Department of Environmental Quality thus simultaneously redistributed and reduced daily acreages burned under northerly wind conditions in 1970. Since the daily decision concerning which acreages to be burned was made early each morning on the basis of the then existing air quality conditions plus predicted meteorological conditions for later in the day, the significant and systematic differences in our regression results for 1969 and 1970 directly follow given the strong relationships established with 1969 data. For example, other things the same, careful control of burning in well-defined priority areas would lead one to expect a decrease in the size and statistical significance of the regression coefficients for relevant acres burned. Similarly, controlled variations in aggregate acres burned according to visibility-before-burning and accurately predicted afternoon meteorological conditions would be expected to increase the size and significance of the 7 a.m. visibility regression coefficients but reduce the size and significance of the coefficients for both acres burned and afternoon inversion

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* Ibid., pp. 1-2.

height. Consequently, the observed shifts in the size and significance of regression coefficients are the result of the 1970 burning program.

Of course, if the 1970 burning program had not been effectively implemented, the large changes in our regression results between 1969 and 1970 would be especially discomforting. Fortunately, available data clearly suggests that, in fact, the 1970 burning program was effectively implemented. For example, the mean 1970 daily acreages burned in the North and South Valley under northerly wind conditions were respectively 10.6 and 53.1 percent lower than the 1969 acreages burned in the same areas under basically identical meteorological conditions. Given this evidence, we conclude that the observed differences in our regression results for 1969 and 1970 derive from the effectively implemented 1970 burning program and not from an incorrect specification of fundamental relationships.

## D. Implications and Tentative Conclusions

The objective of a smoke management policy is the minimization of the harmful effects associated with the smoke produced by the open burning of a given total acreage of agricultural fields. Operationally, smoke management as practiced by the DEQ attempts to minimize visibility losses attributable to field burning smoke in Eugene and Salem. Smoke management thus minimizes rather than eliminates visibility losses in certain areas, while undoubtedly increasing visibility losses in other areas. Viewed most broadly, the foregoing results clearly establish that smoke management can successfully reduce visibility losses from field burning smoke in Eugene and Salem. Moreover, our results suggest that reductions in total acres burned (Tables II.1 and II.2) and especially acres burned between Salem and Eugene (Tables II.3 and II.4) would greatly facilitate successful smoke management. Although the similar size of the regression coefficients for North and South Valley acres burned in Tables II.3 and II.4 would appear to indicate that minimum visibility in Eugene would respond similarly to changes in North or South Valley acres burned, this is, in fact, not the case. The large beta coefficients associated with acres burned in the South Valley provide strong support for the position that successful smoke management requires reductions in acres burned in the South Valley.

Possibly even more important for policy purposes, however, is the following application of our regression results. The 1970 DEQ burning program concurrently (1) altered the geographical distribution and (2) reduced the total acres burned considerably below 1969 levels. Since either a geographic redistribution of the burning or a reduction in acres burned would improve visibility in Eugene, it is reasonable to ask the respective contributions each of these smoke management policy tools made to the observed improvement in Eugene visibility between 1969 and 1970. This was done in the following fashion.

Employing our 1969 regression results for model variants II and III (from Tables II.1 and II.3) and 1970 acres-burned and meteorological data, we first calculated a "predicted" 1969-70 percentage change in mean minimum Eugene visibility, assuming 1970 acres-burned to be geographically distributed as acres-burned were distributed in 1969. A comparison of our predicted percentage change with the actual 1969-70 change showed that the 1969-70 acreage reductions (18.9% for the entire Valley, but 10.6% and 53.1% in the North and South Valley, respectively) accounted for (1) only about 34 percent of the improvement in Eugene minimum visibility when the results reported in Table II.1 are used, but (2) 52-54 percent of the improvement when the results from Table II.3 are employed. Consequently, it appears reasonable to conclude that probably not more than half of the 1969-70 improvement in Eugene visibility is attributable to the reduction in acres burned in the Valley under northerly wind conditions. Moreover, perhaps as much as two-thirds of the 1969-70 improvement in Eugene visibility resulted from the controlled 1970 geographic distribution of acres-burned according to predicted late morning and afternoon meteorological conditions. All of which suggests that perhaps most of the success of the 1970 DEQ burning program and schedule derived from (a) accurate meteorological forecasts and (b) control over the geographic distribution of acres-burned rather than the reduction in acres-burned.

Finally and most obviously, the regression results reported in Tables II.2, 4, 6, and 10 permit calculation of the probable changes in Eugene and Salem visibility with different acreages burned. Since these regression results were obtained from 1970 data, such estimates of visibility changes would necessarily reflect the 1970 DEQ burning program that will be repeated with only minor modifications in 1971. Consequently, trade-offs between Eugene and Salem visibility are easily calculated from our statistical findings. For example, employing model variant II or III results from Tables II.4 and II.10, a reduction in acres burned in the South Valley under northerly winds sufficient to increase mean minimum Eugene visibility for 5 days by 1.0 miles would decrease mean minimum Salem visibility for 2 days by 1.2 miles if those acres were burned under southerly wind conditions.

# III. MEASUREMENT OF THE COSTS OF REGULATING OPEN FIELD BURNING IN THE WILLAMETTE VALLEY

## A. The Methodological Framework

Oregon seed growers dominate United States production of certain seed crops, in large part because Oregon growers have adopted the annual practice of open burning of fields to control various seed diseases and to dispose of harvest residues. At present and in the foreseeable future, field burning constitutes the least-cost method of disease control and residue disposal. Various types of burning regulations would demonstrably increase total costs per acre (see Table I.4), lower yields and seed quality after the first year of regulation, decrease short-run United States supplies of ryegrass and other seeds, and tend to increase United States and world prices of the major types of seed raised in the Willamette Valley. Consequently, the consumers of seed, the owners of Willamette Valley seed and marginal agricultural land, and the owners of specialized capital in the Oregon seed-cleaning and processing industry would share the costs of regulated or banned field burning to reduce pollution.

Here, we briefly specify the methodological framework to be employed for estimation of the losses incurred by Willamette Valley seed growers, land owners, and seed processers following the introduction of various smoke management and/or open-burning ban policies. A fundamental feature of our methodology is the hypothesis that the size of losses incurred by growers, processers, and land owners depend upon the types of regulations imposed. Of course, without this hypothesis there would be no justification for a benefit-cost analysis of alternative control policies.

The methodological framework presented here has the capacity to deal with each of the following major types of field burning control policies:

(1) Policies which directly attempt to change grass seed production processes by (a) direct production process regulation or (b) taxes or subsidies on the use of particular inputs or combinations of inputs; and

(2) Policies which restrict grass seed output but only indirectly change seed production processes by (a) effluent fees, (b) various sorts of taxes on (or related to) output, or (c) different types of acreage controls.

Of course, all of the above policies directly or indirectly change demands for factors of production by directly or indirectly reducing aggregate output and/or changing input-output relationships in the Willamette Valley

seed industry. Moreover, all of these policies have similar impacts on seed prices, aggregate seed outputs, and the geographical distribution of that output.

To illustrate the similar price and output effects of two quite different field-burning regulation policies, consider the effects of (1) a legislated restriction in acreage devoted to seed production in the Willamette Valley with field burning permitted (but well-regulated according to prevailing and forecast air quality and meteorological conditions) on acreage remaining in seed production and (2) a ban on all open field burning in the Willamette Valley. The acreage restriction and ban policies may be most easily illustrated with the aid of Figures III.1 and III.2, respectively, where

$D$ = aggregate demand schedule for seed

$S_O$ = Oregon supply schedule for seed in the absence of an open field burning regulation policy

$S_N$ = supply curve for seed produced outside Oregon

$S_\Sigma$ = aggregate supply schedule for seed with no field-burning regulations.

Before the adoption of either burning control policy, the price and aggregate output of seed would equal OP and OQ, respectively. Oregon output would equal $Oq_O$, and output outside Oregon would be $Oq_N$. Although an acreage restriction (see Figure III.1) and a ban on open burning (see Figure III.2) would unquestionably shift the Oregon supply curve differently, the shift of $S_O$ to $S_{OR}$ in both cases would shift $S_\Sigma$ leftward to $S_{\Sigma R}$, increasing price to $OP_R$, increasing output outside Oregon to $Oq_{NR}$, and reducing Oregon output to $Oq_{OR}$. Of course, the magnitude of each of these changes would depend on (a) the regulation-induced shifts in the Oregon supply schedule and its elasticity before and after the adoption of the regulation, (b) the elasticity of the supply schedule for seed produced outside Oregon, and (c) the elasticity of demand(s) for seed. In turn, changes in prices and outputs would reduce incomes earned by owners of inputs employed in the seed industry.

Although the price-elasticity of seed supply outside Oregon is a crucial determinant of the magnitude of the price, output, and consequent income changes just described, it is clear that Willamette Valley output of grass seed would decline following the introduction of open field burning regulations of either type A or B. A decline in the derived demand for land for grass seed production follows the decline in output. The negative shift being greatest for those field burning control policies that reduce seed production profits most. In any event, given non-zero

Figure III.1

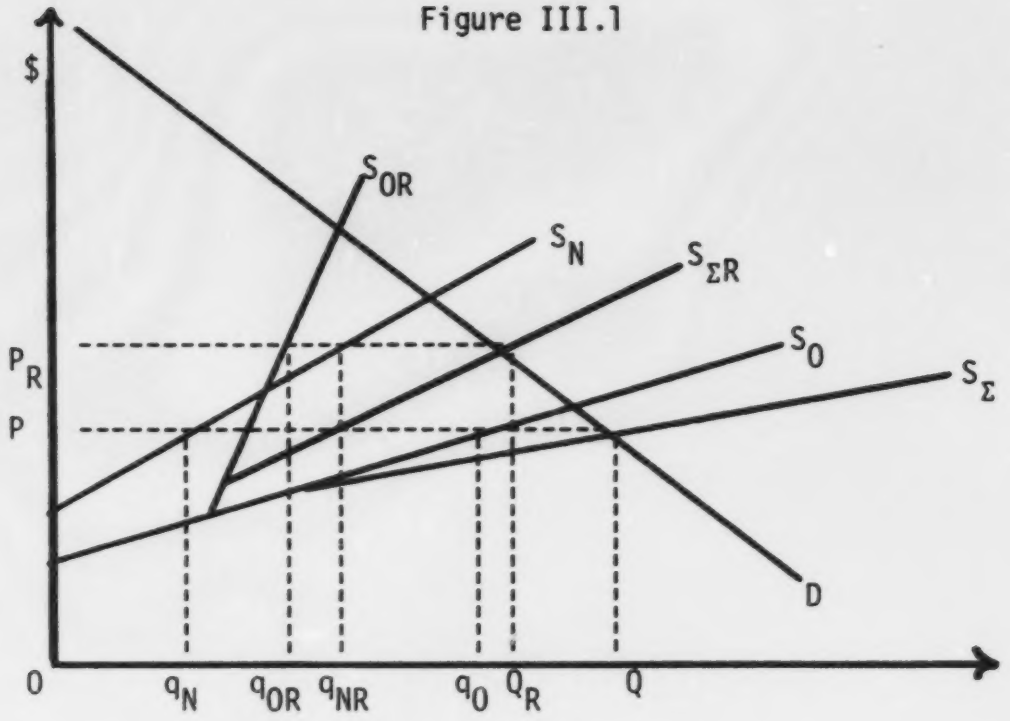
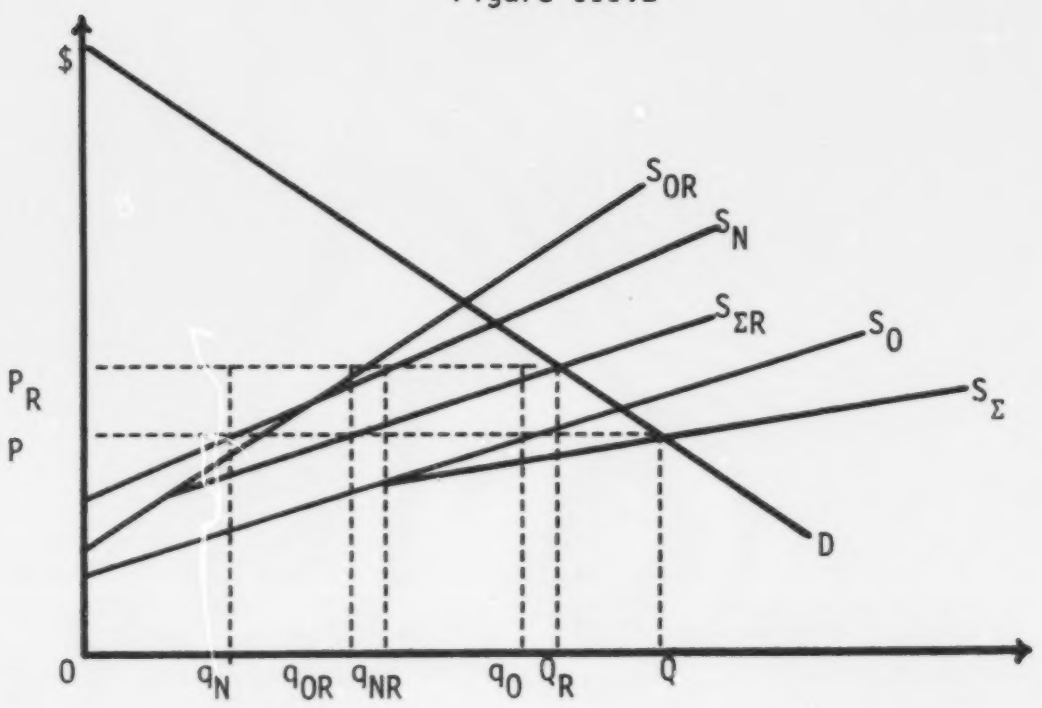



Figure III.2



price elasticities for Willamette Valley land in other uses, the decline in net incomes earned in the seed industry would not be fully capitalized into the value of land now in seed production. (Moreover, this would be true even if supplies of non-land inputs in seed production were price-inelastic.)

This important point can be shown with the aid of Figure III.3, where

$D_S$ = demand schedule for Willamette Valley seed land in the absence of an open field burning regulation policy

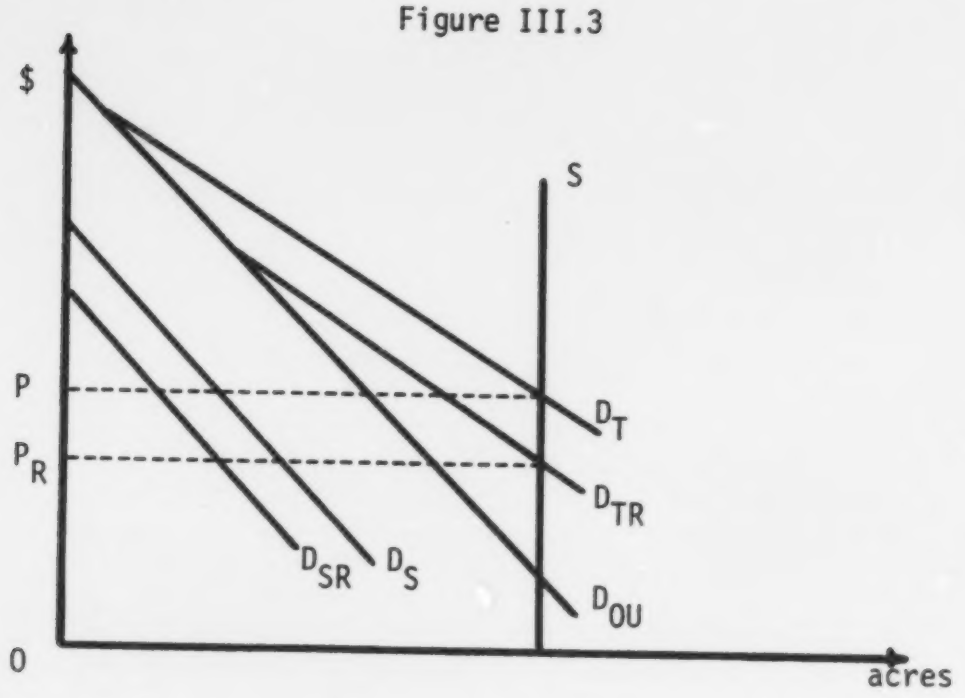
$D_{OU}$ = demand for Willamette Valley land for uses other than seed production

$D_T$ = aggregate demand for Willamette Valley land with no field burning control policy

S = supply of land in Willamette Valley.

Following the introduction of, say, a ban on open field burning, the derived demand schedule for seed land would shift $D_S$ and $D_T$ to $D_{SR}$ and $D_{TR}$, respectively, thereby lowering land prices from OP to $OP_R$. (For expositional convenience, $D_{OU}$ is here postulated to be unaffected by the change in air quality that would result from the ban of burning.)

Figure III.3



Of course, owners of non-land inputs employed by the Willamette Valley seed industry would also experience changes in their incomes following the seed price and output changes induced by control of open field burning. For example, the derived demand for specialized equipment used in growing, processing and cleaning grass seed would decline. The aggregate marginal efficiency of capital schedule of the industry would shift leftward, perhaps also becoming more elastic. The decline in the rate of return in the industry would only be temporary, however. After a period of adjustment during which some owners of specialized capital would experience capital losses, rates of return in the industry would return to those obtained in other industries. The magnitude of these losses would therefore depend on the regulation-induced shift in demand for capital and the length of the "adjustment period".

Summarizing the conclusions of the analysis to this point, the price, output, and income changes consequent to the control of open field burning would depend on (a) the type of regulation imposed, (b) the shift in input-output relationships in the industry, (c) the elasticities of demand for the major seed varieties grown in the Willamette Valley, (d) the elasticity of seed supplies outside Oregon, (e) the elasticities of demand for Willamette Valley land in uses other than seed production, and (f) the elasticities of supply for inputs at least partially specialized in seed production.

Given the research objective of estimating the benefits and costs to Oregonians associated with alternative controls on open field burning, and given the above analysis, we began three investigations in fiscal year 1971:

(1) Estimation of an econometric supply-and-demand model of the seed industry;

(2) Estimation of the determinants of agricultural land values in the seed-growing area of the Willamette Valley; and

(3) Determination of specialized investments in the Oregon seed industry, as well as land rental, leasing, and share-cropping arrangements among landowners and growers.

These investigations, as well as additional ones commencing in July 1971, have been structured to provide the information required to predict the price, output, and income changes consequent to field burning regulation, and they will be completed during the first six months of fiscal 1972. During the first four months of calendar 1972, price, output, and income predictions will be derived and the costs of alternative regulation schemes to Oregonians will be developed.

During fiscal year 1971, particular attention was devoted to the estimation of the determinants of agricultural land values and that investigation is very close to completion. Consequently, our results are

fully reported in the next section of this report. In contrast, no similar extensive presentation of our results are given here for our other projects. We consider, for example, our present estimate of the retail price-elasticities of demand for ryegrass and other seeds as only preliminary estimates, very likely to be revised upon re-estimation during the next few months. Therefore, it seemed unwise to report our tentative results in detail.

## B. The Determinants of Agricultural Land Values in the Willamette Valley

Despite the simplicity of the model presented in the preceding section, one major conclusion appears inescapable. Other things equal, control of field burning in the Willamette Valley would distribute capital losses among land owners, and the size and distribution of those losses would depend principally on the character of the demands for land in the Valley for uses other than production of grass seed. Consequently, a statistical investigation of the determinants of land values in the Willamette Valley was undertaken. The results of that study are reported here.

Primary emphasis in the study was given to the determinants of the intra- and inter-county structure of land values in the eight Willamette Valley counties where substantial quantities of grass seed are raised. The eight counties purposely selected for inter-county study are Benton, Clackamas, Lane, Linn, Marion, Polk, Washington, and Yamhill. In contrast, the particular 72 grass seed operations included in our land value study constitute a subset of a larger sample of seed operations from which we could determine the ownership of 161 parcels (at different locations) in seed production during 1970 and thereby secure county assessment records for each parcel.* This subset of operations permitted intensive intra- and inter-county study of land values only for Benton, Linn, and Marion Counties. Fortunately, this appears quite appropriate because Linn and Benton Counties are major producers of ryegrass, while Marion County leads all other Oregon counties in the production of bentgrass, red fescue, and chewing fescue. These seed varieties are among those that Oregon dominates the nation in production.** The statistical results reported therefore encompass the geographical area of concern quite well.

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* The large sample was selected by means of a two-stage sampling technique for a detailed industrial-organization-type study of the Willamette Valley seed industry. Within each county seed operations were selected at random.

** Middlemiss, W.E. and R. O. Coppedge, *Oregon's Grass and Legume Seed Industry in Economic Perspective*, Special Report 284, Cooperative Extension Service, Oregon State University, Corvallis, Oregon. April 1970.

Here, least-squares multiple-regression analysis provides the analytical tool for our empirical investigation of the determinants of both agricultural land market values and agricultural land value differentials. Land value differentials are defined as the difference between the market and farm use values, where farm use value equals the capitalized value of the assessor's estimate of the rent at which the land could presently be leased. The determinants of land value differentials, as well as market values, are investigated here because such differentials are large, positive, exhibit greater variance than market values per acre, and necessarily reflect the higher future earnings anticipated from Willamette Valley land now in agricultural use.

## 1. The Model

The basic hypothesis of our model is that the market value of any parcel of agricultural land depends on the capitalized value of the parcel's current and expected future net earnings. Of course, since current and future uses of any given parcel of land are not likely to be the same in a rapidly urbanizing area, current land values are unlikely to be closely related to current net earnings. Such land would generally be anticipated to be converted to new agricultural or non-agricultural uses in the future, and a parcel's expected earnings in those new uses would be the major determinants of the parcel's current market value. Therefore, our basic hypothesis requires reformulation for purposes of testing.

Recalling that land now in agricultural use may remain in agricultural use or be converted to non-agricultural use at some point in the future, at least two independent variables (or indices) would appear required "to capture" the dual influence of these possibilities on current land values. To be precise, we hypothesize that current and expected future earnings in agricultural uses are directly related to a consistent and well-defined index of soil quality, while expected future earnings in non-agricultural uses are directly related to the relative accessibility of land parcels to nearby urban centers. Although neither of these hypotheses is particularly unusual when compared to those made in other studies of agricultural land values, the particular soil quality index selected and the absence of data aggregation of the usual sort jointly distinguish this research effort from those undertaken previously.

Dealing first with data aggregation and future conversion to non-agricultural uses, we follow previous studies by measuring the accessibility of land parcels in terms of highway distance to the nearest town with a population over 1,000 but do so for each of the 161 different parcels of land in our sample of 72 farms. Previous investigations, however, have treated farms, even farms composed of non-contiguous land parcels, as the relevant units for study. Consequently, in contrast to these other agricultural land value studies, this one avoids the bias in accessibility measurements introduced when non-contiguous land parcels are treated analytically as if such parcels were contiguous.

Turning now to our hypothesis concerning expected future earnings in agricultural uses, we suggest that future productivity and earnings are more closely and directly related to informed judgment concerning a parcel's soil quality than to the parcel's current net earnings. This seems reasonable because current earnings necessarily reflect basic soil quality, the entreprenuerial effort of the current operator, and current land use. However, given the existence of well-functioning agricultural land and commodity markets, better quality soils would generate higher than average earnings per acre, and vice versa. On such assumptions, therefore, a consistent and well-defined index of soil quality could serve as a proxy for expected future earnings in agricultural uses.

To devise a continuous index of soil quality suitable for use in a multiple-regression study of land values is no simple task. In fact, soil quality is multi-dimensional and would reflect, in combination, soil texture, depth of surface soil, nature of subsoil, fertility, etc. Fortunately for present purposes, agricultural land in the Willamette Valley is typically assessed in terms of its "farm use value," which equals the capitalized value of the county assessor's estimate (for assessment purposes only) of the rent at which it could presently be leased. Given the relatively high level of professional skill demanded of Oregon assessors, as well as the requirement that he treat properties uniformly, this rent estimate provides a consistent and continuous index of soil quality based on informed judgment. Moreover, the assessor's judgment necessarily reflects, albeit imperfectly, the weights the market presently establishes on the various dimensions of soil quality.

Finally, it should be noted that the degree of association between the accessibility (or "urban influence") variables and market values are expected to vary among counties according to the county's present urbanization and the importance attached to future conversion of agricultural land to urban uses by different assessors. For this reason, some experimentation with dummy variables reflecting county urbanization seemed appropriate and is reported here.

## 2. Statistical Results

Three variants of our basic model have been tested against agricultural land market value and differential value data for Benton, Linn, and Marion Counties individually and jointly, as well as for the eight Willamette Valley counties together. These variants differ from one another in terms of their respective specifications of the independent variables and the assumed functional forms assumed for analysis. The model variants are as follows:

$$\text{I.} \quad V = V_I(SQ, DT)$$

$$\text{II.} \quad \text{Log}V = V_{II}(\text{Log } SQ, \text{Log } DT)$$

$$\text{III.} \quad V = V_{III}(SQ, DT, D_1, D_2)$$

where V = assessed market value per acre or assessed farm use value, SQ = current rent per acre, i.e., our index of soil quality, DT = distance to nearest town with population over 1,000, $D_1$ = dummy variable equal to 1 if population of the nearest town is greater than 1,000 but less than 10,000 and zero otherwise, and $D_2$ = dummy variable equal to 1 if the population of the nearest town is greater than 10,000 but less than 20,000 and zero otherwise.

Tables III.1 through III.6 report our regression results for model variants with agricultural land market values per acre as the dependent variable, while Tables III.7 through III.11 present the results obtained with land value differentials per acre as the dependent variable.

With regard to our market value results, it is important to note that all estimated regression coefficients reported in Tables III.1 - III.6 have the expected signs and support the hypotheses of our basic model.* Moreover, Tables III.3 and III.4 indicate that model variant II performs exceedingly well when judged by the usual statistical tests, particularly when one compares its performance with that of variants I and III when tested on combined three and eight county data. In terms of goodness of fit as measured by $R^2$ and the F-statistic, model variant II performs better than either variant I or III, and both estimated regression coefficients are statistically significant at the one percent level and properly signed.

Two features of the regression results deserve special comment. First, Marion County's relatively large constant terms and distant-to-town t-statistics are consistent with the hypothesis that urbanization has had a greater influence on agricultural land values there than in Benton and Linn Counties. In fact, if urbanization is measured by aggregate county population, population of the largest city in the county, or total retail sales, Marion County would be classified as more ubanized than either Benton or Linn Counties. Second, for model variant II, the

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* Since dummy variables are essentially intercept shifters, no hypotheses with regard to their signs are supported or rejected by the results reported in Tables III.5 and III.6.

Table III.1

Market Values

Regression Results: Model I For Benton, Linn, and Marion Counties Separately

| | Benton | Linn | Marion |
|---|---|---|---|
| Constant | 268.1636 | 181.1212 | 697.5259 |
| Soil quality | 13.4541[a]<br>(8.526) | 10.8166[a]<br>(7.041) | 1.8875<br>(.061) |
| Distance to town | 23.1971[a]<br>(-4.654) | -13.9725[b]<br>(-2.451) | -62.7178[a]<br>(-6.783) |
| $R^2$ | .7859 | .5834 | .7632 |
| $\bar{R}^2$ | .7733 | .5667 | .7450 |
| F-statistic | 62.4034 | 35.0103 | 41.9099 |
| Degrees of freedom | 34 | 50 | 26 |

Note: Figures in parentheses are t-statistics.

[a] Significant at the 1 percent level.
[b] Significant at the 5 percent level.

Table III.2

Market Values

Regression Results: Model I for Benton, Linn and Marion Counties and for all Counties.

| | Three Counties | All Counties |
|---|---|---|
| Constant | 312.8117 | 233.5416 |
| Soil quality | 8.7354[a]<br>(7.028) | 10.9942[a]<br>(9.598) |
| Distance to town | -21.9800[a]<br>(-5.616) | -15.1824[a]<br>(-4.409) |
| $R^2$ | .5415 | .4927 |
| $\bar{R}^2$ | .5336 | .4863 |
| F-statistic | 68.4915 | 76.7273 |
| Degrees of freedom | 116 | 158 |

Note: Figures in parentheses are t-statistics.

[a] Significant at the 1 percent level.

Table III.3

Market Values

Regression Results: Model II for Benton, Linn and Marion Counties Separately

| | Benton | Linn | Marion |
|---|---|---|---|
| Constant | 2.0676 | 1.6597 | 2.3416 |
| Soil quality | 0.6759[a]<br>(10.154) | 0.7232[a]<br>(10.63) | 0.4872[a]<br>(3.194) |
| Distance to town | -0.4653[a]<br>(-4.599) | -0.1432[a]<br>(2.97) | -0.5691[a]<br>(-4.801) |
| $R^2$ | .8197 | .7479 | .7144 |
| $\bar{R}^2$ | .8091 | .7378 | .6924 |
| F-statistic | 77.2835 | 14.83 | 32.5105 |
| Degrees of freedom | 34 | 50 | 26 |

Note: Figures in parentheses are t-statistics.

[a] Significant at the 1 percent level.

Table III.4

Market Values

Regression Results: Model II for Benton, Linn and Marion Counties Combined and for all Counties

| | Three Counties | All Counties |
|---|---|---|
| Constant | 1.9587 | 1.8497 |
| Soil quality | 0.5944[a] (10.886) | 0.6333[a] (12.975) |
| Distance to town | -0.2652[a] (-5.625) | -0.1731[a] (-4.695) |
| $R^2$ | .6581 | .5980 |
| $\bar{R}^2$ | .6527 | .5928 |
| F-statistic | 111.6228 | 117.5392 |
| Degrees of freedom | 116 | 158 |

Note: Figures in parentheses are t-statistics.

[a] Significant at the 1 percent level.

Table III.5

Market Values

Regression Results: Model III for Benton, Linn and Marion Counties Separately.

| | Benton | Linn | Marion |
|---|---|---|---|
| Constant | 133.8253 | 139.1472 | 687.4362 |
| Soil quality | 13.4968[a]<br>(10.398) | 10.6798[a]<br>(6.512) | 1.9988<br>(0.584) |
| Distance to town | -7.0758<br>(-1.236) | -13.5581[b]<br>(-2.313) | -62.2614[a]<br>(-6.223) |
| Dummy 1 | -22.4137<br>(-1.193) | 42.0792<br>(0.867) | 7.2854<br>(0.156) |
| Dummy 2 | 110.8673[a]<br>(3.252) | 58.2341<br>(1.120) | -4.1374<br>(-0.038) |
| $R^2$ | .8643 | .5942 | .7636 |
| $\bar{R}^2$ | .8473 | .5598 | .7242 |
| F-statistic | 50.9357 | 17.5690 | 19.3794 |
| Degrees of freedom | 32 | 48 | 24 |

Note: Figures in parentheses are t-statistics.

[a] Significant at the 1 percent level.
[b] Significant at the 5 percent level.

Table III.6

Market Values

Regression Results: Model III for Three Counties; Benton, Linn and Marion Combined.

| | Three Counties |
|---|---|
| Constant | 326.6881 |
| Soil quality | 8.4352[a]<br>(6.583) |
| Distance to town | -22.1400<br>(-5.466) |
| Dummy 1 | -13.0011<br>(-0.515) |
| Dummy 2 | 14.4446<br>(0.432) |
| $R^2$ | .5467 |
| $\bar{R}^2$ | .5278 |
| F-statistic | 34.3711 |
| Degrees of freedom | 114 |

Note: Figures in parentheses are t-statistics.

[a] Significant at the 1 percent level.

Table III.7

Land Value Differentials

Regression Results: Model I for Benton, Linn and Marion Counties Separately.

| | Benton | Linn | Marion |
|---|---|---|---|
| Constant | 279.9287 | 165.4939 | 768.8398 |
| Soil quality | 2.8872<br>(1.832) | 0.4198<br>(0.265) | -10.1798[a]<br>(-3.4187) |
| Distance to town | -23.9125[a]<br>(-4.804) | -13.1903[b]<br>(-2.240) | -69.7724[a]<br>(-7.8276) |
| $R^2$ | .4972 | .1045 | .7132 |
| $\bar{R}^2$ | .4676 | .0687 | .6911 |
| F-statistic | 16.8120 | 2.9163 | 32.3231 |
| Degrees of freedom | 34 | 50 | 26 |

Note: Figures in parentheses are t-statistics.

[a] Significant at the 1 percent level.
[b] Significant at the 5 percent level.

Table III.8

Land Value Differentials

Regression Results: Model I for Three Counties; Benton, Linn and Marion Combined and for all Counties.

| | Three Counties | All Counties |
|---|---|---|
| Constant | 311.3299 | 234.6726 |
| Soil quality | -2.0002<br>(-1.574) | 0.3904<br>(0.333) |
| Distance to town | -21.2569[a]<br>(-5.311) | -14.9188[a]<br>(-4.229) |
| $R^2$ | .1982 | .1171 |
| $\bar{R}^2$ | .1844 | .1059 |
| F-statistic | 14.3379 | 10.4816 |
| Degrees of freedom | 116 | 158 |

Note: Figures in parentheses are t-statistics.

[a] Significant at the 1 percent level.

Table III.9

Land Value Differentials

Regression Results: Model II for Benton, Linn and Marion Counties Separately.

| | Benton | Linn | Marion |
|---|---|---|---|
| Constant | 2.6075 | 1.9992 | 2.8629 |
| Soil quality | 0.3180[b] (2.152) | 0.1838 (0.997) | 0.3649 (0.097) |
| Distance to town | -1.0240[a] (-4.599) | -0.4046[a] (-3.095) | -1.0638[a] (-3.625) |
| $R^2$ | .4828 | .2072 | .4097 |
| $\bar{R}^2$ | .4528 | .1755 | .3643 |
| F-statistic | 15.8718 | 6.5354 | 9.0237 |
| Degrees of freedom | 34 | 50 | 26 |

Note: Figures in parentheses are t-statistics.

[a] Significant at the 1 percent level.
[b] Significant at the 5 percent level.

Table III.10

Land Value Differentials

Regression Results: Model II for Three Counties; Benton, Linn and Marion Combined and for all Counties.

| | Three Counties | All Counties |
|---|---|---|
| Constant | 2.3788 | 2.1778 |
| Soil quality | 0.0487<br>(0.361) | 0.1325<br>(1.127) |
| Distance to town | -0.5185[a]<br>(-4.454) | -0.3492[a]<br>(-3.930) |
| $R^2$ | .1730 | .1130 |
| $\bar{R}^2$ | .1588 | .1018 |
| F-statistic | 12.1366 | 10.0744 |
| Degrees of freedom | 116 | 158 |

Note: Figures in parentheses are t-statistics.

[a] Significant at the 1 percent level.

Table III.11

Land Value Differentials

Regression Results: Model III for Benton, Linn and Marion Counties Separately.

| | Benton | Linn | Marion |
|---|---|---|---|
| Constant | 120.5948 | 130.6073 | 700.1061 |
| Soil quality | 3.1019[b]<br>(2.489) | 0.2898<br>(0.170) | -8.7482[b]<br>(-2.586) |
| Distance to town | -5.4457<br>(-1.006) | 112.8631[b]<br>(-2.115) | -63.3860[a]<br>(-6.415) |
| Dummy 1 | -21.1583<br>(-1.175) | 35.2514<br>(0.700) | 4.5226<br>(0.098) |
| Dummy 2 | 126.4737[a]<br>(4.008) | 49.6798<br>(0.921) | -2.9568<br>(-0.028) |
| $R^2$ | .7147 | .1204 | .6670 |
| $\bar{R}^2$ | .6790 | .0456 | .6115 |
| F-statistic | 20.0400 | 1.6419 | 12.0167 |
| Degrees of freedom | 32 | 48 | 24 |

Note: Figures in parentheses are t-statistics.

[a] Significant at the 1 percent level.
[b] Significant at the 5 percent level.

size and statistical significance of our soil quality regression coefficients is relatively greater and the distance-to-town coefficient relatively smaller for Linn than for Benton and Marion Counties. Such results are consistent with the hypothesis that Linn County land has the lowest potential convertibility to non-seed agricultural or non-agricultural uses among the three counties. Qualitative evidence in support of this hypothesis derives from (1) the poorer quality soil in Linn as opposed to Benton and Marion Counties and (2) the lesser present, and hence forecast future, urbanization of Linn County. Consequently, model variant II (see Table III.3 and III.4) performs rather well with agricultural land market values per acre as the dependent variable.

Turning next to our findings when agricultural land value differentials are the dependent variable, Tables III.7 through III.11 report poorer regression results than those discussed above. This general finding cannot be regarded as surprising, however, because land value differentials (1) have a much greater variance than market values and (2) presumably reflect other factors than those associated with current agricultural use. Without an increase in the number of independent variables, therefore, one would reasonably expect less satisfactory performance of our basic model. Nonetheless, the following features of our results are noteworthy.

First, as before, model variant II performs better than variants I and III. Tables III.9 and III.10 show all estimated regression coefficients have their theoretically anticipated signs and relatively uniform $R^2$ and F-statistics for model variant II. The multiplicative functional form assumed for variant II once again appears more appropriate than the additive form most often used in land value investigations. Of course, the high degree of statistical significance for the distance-to-town variable supports our basic hypothesis that land parcels located more closely to existing urban areas are more likely to be converted to non-agricultural uses in the future. Additional evidence in support of this hypothesis may be derived from a comparison of the size of the distance-to-town regression coefficients in Tables III.3, III.4, III.9, and III.10. Such comparisons indicate that the coefficients estimated with differentials as the dependent variable are approximately twice the size of the coefficients estimated with market value data. Finally, the lack of statistical significance for the estimated soil-quality regression coefficients in Tables III.9 and III.10 indicate that agricultural land value differentials in the Willamette Valley are apparently <u>not</u> "explained" by either intra- or inter-county variation in potential productivity in agricultural uses.

Since land value differentials are calculated in a fashion to minimize, though undoubtedly not eliminate, the influence of current earnings from agricultural use, our land value differential regression results usefully supplement the market value results and lead us to the following tentative conclusions. First, the structure of agricultural land values in the Willamette Valley reflect urban influences in much the same fashion

as location theory would predict and as other studies have discovered elsewhere. Second, prospective urbanization and urban influences rather than prospective continued agricultural use dominate the structure of agricultural land values throughout the Willamette Valley.

### 3. Conclusion

For the purposes of measuring the costs associated with control of open field burning in the Willamette Valley, the most important results obtained are those reported in Table III.4. Despite inter-county variation in the relative importance of the factors that statistically account for variations in agricultural land values, our basic model performs rather well when tested against data from (1) the three major and (2) all eight seed-producing counties. These results suggest the existence of a relatively "well-behaved" agricultural land value surface extending across county boundaries in the Willamette Valley. Since measurement of the costs to landowners of controlling open field burning requires estimation of the regulation-induced shifts in the agricultural land value surface, our success in empirically estimating the existing surface suggests that the cost measurement methodology sketched earlier in this report can be implemented during fiscal year 1972.

# IV. THE IMPACT OF AIR QUALITY VARIATIONS ON TOURIST RELATED INDUSTRIES

The "economic effects" portion of this research contract is committed to establishing, in whole or in part, what the social costs are of air pollution. This particular portion of the research contract is attempting to ascertain whether the existence of presumed social costs can be supported by studying a particular class of economic activities. These are, namely, activities that might be called outdoor or tourist-related activities. In particular, prior theoretical analysis has suggested that air pollution or air quality variation affects the choices of consumers and, by implication, alters the consumption set that they enjoy and, by further implication, produces social costs. The theory is clear, albeit complex. The model specification has consumption expressed in terms of activities that are 'produced' by combining various proportions of market commodities and time. Thus far, the specification of a research design to test the theoretical implications has been slowed by the twin problems of (1) how to specify consumption activities and (2) what rationale might be used for specifying which activities would be affected positively and which activities would be affected negatively upon variation in air quality. Previously, answers to these problems appeared to be required prior to specifying the objectives of the third year research which would proceed under this contract. Reflection on the overall objective of this research project, the availability of knowledge on the effects of air pollution, and on the specification of consumption activities, and on the availability of data suggests the following course for the third portion of this research.

Tests of the existence of social costs related to air quality variation require data on the variation in air quality. In the Willamette Valley, the primary source of variation in air quality stems from the process of field burning and this occurs primarily in the summer months of July, August, and September. Previous research has shown that air quality, as measured by hogizontal visibility, can be related directly to the number of acres of grass straw burned and the prevailing atmospheric conditions. It is also clear that air quality is tied to the burning policy applicable in the area. This policy is established by the Department of Environmental Qaulity and has changed since our previous research. As the policy stands, the determination of areas where burning is permissible on a given day is related to the prevailing atmospheric conditions. Previous econometric research would suggest that the areas of considerable deterioration in air quality can be predicted on the basis of those atmospheric conditions. Further, points of maximum deterioration in air quality should move around the Willamette Valley with the pattern of movement influenced primarily by prevailing wind directions and the levels of temperature inversions.

Previous analysis has argued there are sound reasons for focusing on consumption activities that might be labeled outdoor, recreation, or

tourist-related. Within the Willamette Valley the facilities, either public or private, that might be used in conjunction with any such activities are finite in number. That is, within the Valley there are a limited number of day-visit and overnight camping facilities, museums, public points of interest, golf courses, etc. For analytical purposes, the number of such facilities can be classified and limited in several ways. They can also be identified by geographic area of the Valley.

The consumption activities we are concerned with can theoretically be specified in terms of the amounts of market commodities, public facilities, and time required to produce a given kind of consumption activity. We have assumed that the proportions are fixed; that is, that the technologies are linear. Operating on this assumption, and given knowledge of the availability and location of public and private facilities that go into the production of these outdoor consumption activities, we propose a slight revision in research tack in this research. In particular, rather than specifying in advance the technical properties of the consumption activities in question, we propose to examine the relationship between the attendance or use of a selected set of available public or private facilities in the Willamette Valley to air pollution and use these results as an indirect test of the existence of the effects we are looking for. That is, we would predict that in high pollution areas the attendance or use of day-use and overnight camping facilities would fall as air quality deteriorated. Conversely, we would predict that the attendance at facilities such as the State Capitol in Salem would increase in the face of increased air pollution. This analysis would be, again, an indirect test of the existence of those effects we are searching for and, depending upon the research results, the question of how to define the particular activities and how to specify the market commodities associated with those activities can be left as an empirical question to be pursued in research. This proposed test procedure is attractive on two grounds. First, it does provide an indirect test of the kind of effects we have hypothesized. Second, it is a test procedure that has a least initial low costs of data collection in that we need not collect data on a variety of market goods associated with the commodities. If initial research suggests the effects of air pollution are significant, we can proceed to specify and collect data on the market commodities that are related with the use of those public or private facilities.

This test procedure covers activities that we would expect to be inversely related with air pollution as well as those activities that we would expect to be positively related to air pollution. This latter group of activities we have previously named as "substitutes". The procedure does not permit consideration of the full set of substitute activities. That is, there are conceivably consumption activities using facilities on the Oregon coast or on the east side of the Cascade Mountains or out of the state that might be substituted for activities consumed in the Willamette Valley in the face of higher pollution counts. However, before proceeding to specify and collect data on the activities consumed in these other areas, there is a question that should receive prior consideration. The question is, are

consumers, and tourists in particular, sufficiently "tracked" in their consumption behavior so that variation in air quality will only affect the selection of consumption activities in a small region, or do these consumers have sufficient flexibility, or are the effects of air quality sufficiently strong, to lead the consumers to look some distance for available alternative activities? This question is of sufficient research import to be regarded as an empirical question and the answer to which should be regarded as an objective of research. A reasonable approximation to an answer of this question can be obtained by opinion sampling.

At the end of this report, designated Illustration IV.1 is a questionnaire that is proposed for administration during the latter half of the month of July and into the month of August primarily in the Willamette Valley of Oregon*. The questionnaire is designed to:

1. Select for out-of-state persons traveling for pleasure,
2. Identify the type of area from which they came,
3. Identify the routes they plan to travel,
4. Identify the type of activities they planned to enjoy on their vacation prior to departing home and to obtain an idea of the relative amounts of time they planned to allocate to each activity,
5. Determine whether those pre-vacation plans have changed enroute,
6. Determine why any such changes occurred,
7. Focus on the possible impact of air pollution or air quality variation on those travel plan changes,
8. Estimate the dollar value or cost required for those changes,
9. Determine the perceptions of the relative amounts of air pollution in Oregon, vis-a-vis the areas from which they came,
10. Obtain various demographic data on the population sampled.

---

*This questionnaire was submitted for Bureau of Budget approval on May 28, 1971. All requisite supplementary material was attached. This questionnaire was pretested in the Portland and Salem areas in early May, 1971.

There are several possible potential sample frames to draw on to obtain the required data. The sample frame proposed is the out-of-state travel set that stops at motels or at roadside rests overnight. This frame was selected due to considerations relating to random sampling procedures. For alternative sample frames, there are inadequate data about the relevant probability distributions or inadequate knowledge of the behavioral differences that might prevail to justify broadening the sample frame.

Present estimated variances suggest that a sample size of 200 is required to obtain a degree of precision of approximately .05. Upon obtaining this number of usable questionnaires, the data are to be coded, key punched and subsequently analyzed using the standard procedures of linear multiple regression and factor analysis. These data should permit the indirect testing of hypotheses relating to:

1. The impact of air quality variation on the pattern of consumption activities consumed,

2. The cost of these impacts,

3. The relative magnitude of air pollution in Oregon vis-a-vis other areas,

4. The type of person or family units influences by air quality variation.

Concurrent with the administration of this questionnaire, an alternative test procedure is planned for the hypothesis that 'variation in air quality makes a difference'. In particular, even though the technical properties of consumption activities are not known a priori, the assumption of linear proportions would allow one to test certain hypothesized relationships which might be specified on the basis of a priori knowledge. A priori considerations would suggest that leisure time activities utilizing substantial relative amounts of outdoor recreation facilities would diminish as air pollution levels rose. Similarly, leisure time activities utilizing indoor facilities should increase under the same circumstances. Drawing upon these a priori considerations, and utilizing the existence of attendance or use data at such outdoor facilities as golf courses and certain day-use park facilities, as well as attendance data at the Oregon State capitol and at various museums in the Willamette Valley, these hypothesized a priori relationships can be subjected to tests with the assistance of the readily available data on horizontal visibility provided by the Salem and Eugene airports. The visibility data can be extensively supplemented with certain other meteorological measurements.

ILLUSTRATION IV.1

Budget Bureau Number
Approval Expires April 30, 1972

May 12, 1971 OREGON STATE UNIVERSITY Final

Hello, I'm working on a survey for Oregon State University and I would like to ask you a few interesting questions, if you don't mind.

1- _____ City
_____ State

First, which city is your permanent residence located in or near?

(NOTE TO INTERVIEWER: If respondent resides in Oregon, terminate interview; otherwise continue)

2- 1 Recreation (Ask Q3)
2 Other only (TERMINATE)
(Specify _____)
3 Both recreation & other (Ask Q3)

Are you traveling in Oregon for recreation or for other purposes?

3- 1 Auto
2 Bus
3 Airplane
4 Other (Specify)_____

What type or types of transportation are you using on your vacation or recreation trip in Oregon?

4- Thinking back to just before you left on your vacation or recreation trip, which place or places were you planning to visit in Oregon?

_____ _____ _____

5- Again, thinking back to just before you left on your vacation or recreation trip, which highway or highways were you planning to use in Oregon to get to your destination(s)?

_____

_____

_____

6- And, which highway or highways were you planning to use to leave Oregon?

_____

7-

| L | QB | LI | N | DK | |
|---|---|---|---|---|---|
| 4 | 3 | 2 | 1 | 0 | Camping |
| 4 | 3 | 2 | 1 | 0 | Boating, water skiing |
| 4 | 3 | 2 | 1 | 0 | Golfing |
| 4 | 3 | 2 | 1 | 0 | Ocean beach activities |
| 4 | 3 | 2 | 1 | 0 | Hiking, walking |
| 4 | 3 | 2 | 1 | 0 | Swimming |
| 4 | 3 | 2 | 1 | 0 | Pleasure driving sightseeing |
| 4 | 3 | 2 | 1 | 0 | Salmon fishing |
| 4 | 3 | 2 | 1 | 0 | Trout Fishing |
| 4 | 3 | 2 | 1 | 0 | Other (Specify)_____ |

Now, here are some specific out-of-door activities. Thinking back to just before you left on this trip, how much time, if any, were you <u>planning</u> to spend participating in each of these activities in Oregon? As I read each activity would you tell me how much time you planned to spend on each one--a lot, quite a bit, a little or none at all?

8- $_____ Including everyone in your party, about how much, in dollars, were you planning to spend in Oregon for your vacation in the state this summer? Just your best estimate?

---

9- Which place or places have you already visited in Oregon on this particular vacation or recreation trip?

_____ _____ _____

---

10- Considering your vacation plans <u>now</u>, which place or places are you planning to visit in Oregon?

_____ _____ _____

---

11- And, considering your vacation plans now, which highway or highways are you planning to use to get to your destination(s) in Oregon?

_____

_____

---

12- Which highway or highways are you planning to use now when you leave Oregon?

_____

---

13- 1 Changed (Ask Q14)
2 Not changed (Skip to Q23)
3 DK, NA (Skip to Q23)

Have your vacation plans for Oregon changed since you arrived in the state, or not?

---

14-

| L | QB | LI | N | DK | |
|---|---|---|---|---|---|
| 4 | 3 | 2 | 1 | 0 | Camping |
| 4 | 3 | 2 | 1 | 0 | Boating, water skiing |
| 4 | 3 | 2 | 1 | 0 | Golfing |
| 4 | 3 | 2 | 1 | 0 | Ocean beach activities |
| 4 | 3 | 2 | 1 | 0 | Hiking, walking |
| 4 | 3 | 2 | 1 | 0 | Swimming |
| 4 | 3 | 2 | 1 | 0 | Pleasure driving sightseeing |
| 4 | 3 | 2 | 1 | 0 | Salmon Fishing |
| 4 | 3 | 2 | 1 | 0 | Trout Fishing |
| 4 | 3 | 2 | 1 | 0 | Other (Specify_____) |

Here are some out-of-door activities. How much time, if any, <u>are</u> you planning to spend now participating in them in Oregon. As I read each activity will you tell me the time you plan to spend now on each one -- a lot, quite a bit, a little or none at all?

---

15- 1 More (Ask Q15a)
2 Less (Ask Q15a)
3 Same (Skip to Q16)
4 DK (Skip to Q16)

The way things look now, will you probably spend more or less money on your vacation in Oregon than you originally planned to?

---

15a- What are the main reasons you will probably spend (more) (less) than you originally planned to? (PROBE)

---

16- I have here a list of reasons some people have given for changing vacation plans in Oregon. As I read each one, would you tell me if it had any effect or not on your plans?

| Yes | NO | DK,NA | |
|---|---|---|---|
| 2 | 1 | 0 | Rain |
| 2 | 1 | 0 | Heat |
| 2 | 1 | 0 | Crowded facilities (What?_____) |
| 2 | 1 | 0 | Air pollution |
| 2 | 1 | 0 | Lack of money |
| 2 | 1 | 0 | Automobile breakdown or accident |
| 2 | 1 | 0 | Sickness in family |
| 2 | 1 | 0 | Other (What?_____) |

(INTERVIEWER: Always ask #17 if code 2 on Air pollution is circled.)
If Air pollution code 2 is not circled, skip to #21)

---

17- What kind or kinds of air pollution in Oregon affected your vacation plans in the state this summer? (PROBE for type and location of air pollution)

---

18- How or in what way or ways did air pollution in Oregon affect your vacation plans in this state? (PROBE!)

---

19- 1 Increased (Ask Q20)
2 Decreased (Ask Q20)
3 No difference (Skip to Q21)
4 DK, NA (Skip to Q21)

Would you say that air pollution in Oregon increased or decreased the amount of money you planned to spend for your vacation in the state this summer?

---

20- $_____

How much of an (increase) (decrease) in dollars, would you say your party is spending in Oregon for your vacation because of air pollution?

---

21- 1 Increase (Ask Q22)
2 Decrease (Ask Q22)
3 No difference (Skip to Q23)
4 DK, NA (Skip to Q23)

(Not counting air pollution) Would you say that the reasons you gave for changing vacation plans in Oregon increased or decreased the amount of money you planned to spend for your vacation in the state this summer?

---

22- $_____

How much of an (increase) (decrease), in dollars, would you say your party is spending in Oregon for your vacation or recreation trip, because of the reasons you gave for changing your vacation plans in Oregon?

---

23- 1 Very
2 Quite
3 Not too
4 Not at all
5 DK

From what you have seen in Oregon, how serious an air pollution problem, if any, do you feel we have -- very serious, quite serious, not too serious or not serious at all?

---

24- 1 Very (Ask 24a)
2 Quite (Ask Q24a)
3 Not too (Ask Q24a)
4 Not at all (Ask Q24a)
5 DK (Skip to Q25)

How serious an air pollution problem, if any, do you feel you have in the area where you live -- very serious, quite serious, not too serious or not serious at all?

---

24a- How or in what way or ways is air pollution a _____problem in the area where you live? (PROBE)

---

25- 1 More in Oregon (Ask Q25a)
2 Less in Oregon (Ask Q25a)
3 Same (Skip to Q26)
4 DK (skip to Q26)

Thinking about clean air again, would you say there is more or less air pollution in Oregon than where you live?

---

25a- How, or in what ways, do you think Oregon has (more) (less) of an air pollution problem than the place where you live?

---

26- ASK OF EVERYONE

_____
no. persons

Including yourself, how many persons are travelling in your party on this particular vacation or recreation trip in Oregon?

---

27- 4 College - complete
3 College - partial
2 High school
1 Grade or no schooling

Would you mind telling me the last grade you completed in school?

---

28-

_____(Type of industry)

_____(Specific job)

What type of work does the chief breadwinner in the family do?

---

29 1 20-29
2 30-39
3 40-49
4 50-59
5 60 & above

May I ask your approximate age?

---

30- BY OBSERVATION

1 Male
2 Female

---

31- 1 Less than 30 minutes
2 30 minutes - 1 hour
3 1 hour - 1 1/2 hours
4 More than 1 1/2 hours

Length of interview

---

32- 3 Positive
2 Neutral
1 Negative

Rating on cooperation

---

X I hereby certify this interview was actually taken at the following address and represents a true and accurate account of the interview.

_____ (Address) _____ (City) _____ (Interviewer's Signature)

_____ Phone Number (For verification only)

Name _____

FOR OFFICE USE ONLY: Interview verified by _____ Date _____

*SOCIAL EFFECTS OF CHANGES IN AIR QUALITY*

*Robert G. Mason*

A theoretical model concerning the effects of air quality changes on people's attitudes and mass media use patterns has been formulated. The central hypothesis is the stipulation that changes in attitude toward, changes in mass media exposure about and level of knowledge about air quality represent an interdependent belief system and that a perceptible change in air quality, as measured by visual range, is sufficient to stimulate a measurable change in the variables of the system. Testing of the model involves two measures of the same individual at two levels of air quality.

The first year's effort was devoted to 1) development and evaluation of operational measures of variables employed in the theoretical model; 2) random selection of individuals in the two target cities, Salem and Eugene, Oregon, who were to be interviewed; and 3) completion of the first interviewing "wave" during May of 1970.

The current, or second, year's objectives were:

1. Completion of interviews and evaluation of response rates.

2. Completion of questionnaire coding, key punching and verification.

3. Completion of visibility observations, or, measures of visual range.

4. Analysis of air quality perceptions of respondents.

The objectives of the second year were met. Each will be discussed in greater detail in the order it was presented above.

I. Completion of interviews and evaluation of response rates.

The study design called for measures of the same individuals during periods of high and low visual range in two Oregon cities. Two interviewing waves were planned. The first, Schedule A, contained measures of both

endogenous and exogenous variables. The second, Schedule B, contained measures of endogenous variables only, since they are postulated to change as an effect of changes in air quality. It was important to insure that use of Schedules A or B was uncorrelated with air quality. Thus, the sample in both cities (Salem and Eugene, Oregon) was drawn so that a random half of respondents would be interviewed from each city in the following manner:

| | May 1970 | September 1970 | January 1971 |
|---|---|---|---|
| | % respondents | % respondents | % respondents |
| Schedule A | 50 | 50 | |
| Schedule B | | 50 | 50 |

May 1970 and January 1971 were periods of relatively high visual range while September 1971 was a period of relatively low visual range in Eugene. Compared to Eugene, Salem experienced greater visual range in September but visibility was lower in September than it was in May or January.

The sampling universe consisted of all adults (over 21 years of age) living in single-family dwelling units in Salem and Eugene, Oregon. Sample size for each city was 300 individuals. Blocks or block-like segments were numbered in serpentine fashion within each census-tract area. It was determined arbitrarily that four households would be selected from each block. Using a table of random numbers, a sufficient number of blocks was drawn to yield the required number of households for contact. Four valid dwelling units were selected at random during an on-site visit to each block. Half the blocks within each census tract were selected at random for the first interview "wave". Respondents within households were determined randomly, using a "face sheet" commonly employed for such purposes.

The first interviewing wave began May 15, 1970 and terminated June 2, 1970. The firm of Bardsley and Haslacher of Portland, Oregon was under contract to perform all interviewing functions. The interview schedules were approved by the Bureau of the Budget, receiving BOB Number 85-S0010. A total of 224 household addresses was specified in each city for each interview. Oversampling was planned in order to secure, if possible, more than 150 completed interviews, since panel attrition may be high for the subsequent re-interviewing with Schedule B.

Interviews for the low visual range condition began August 26, 1970 and were completed September 16, 1970. The third (and final) interview wave began January 5, 1971 and terminated January 16, 1971.

Response rates for Schedule A were calculated by dividing the number of successful completions by 224. Response rates for Schedule B were the number of successful completions divided by the number of usable Schedule A's.

Table 1. Response rates for interviewing

| Interview | Salem | | | Eugene | | |
|---|---|---|---|---|---|---|
| | May 1970 | September 1970 | January 1971 | May 1970 | September 1970 | January 1971 |
| | % | % | % | % | % | % |
| Schedule A | 77 | 87 | | 87 | 78 | |
| Schedule B | | 83 | 87 | | 87 | 87 |

The percent not-at-homes and refusals are presented in table 2. (Percentages in parentheses refer to refusals).

Table 2. Percent not-at-homes and refusals

| Interview | Salem | | | Eugene | | |
|---|---|---|---|---|---|---|
| | May 1970 | September 1970 | January 1971 | May 1970 | September 1970 | January 1971 |
| | % | % | % | % | % | % |
| Schedule A | 14 (9)* | 7 (6) | | 6 (7) | 11 (11) | |
| Schedule B | | 9 (8) | 8 (5) | | 7 (6) | 9 (4) |

*Percentages in parentheses refer to refusals.

The not-at-home rate for Salem in May and the refusal rate for Eugene in September, both with Schedule A, appear high. An examination of block clusters assigned to interviewers revealed no pattern of non-at-homes for Salem. They appeared to be distributed uniformly across all clusters. The distribution in Eugene, however, was concentrated in blocks surrounding the University of Oregon, and interviewers noted the cause of refusal in some instances as a saturation of previous interviewing by University students.

Any effect of Schedule A of non-response may be partially reduced by the definition of the population as residents who would live in their respective dwelling units for six consecutive months or more after contact. A set of items was developed and used for predicting early in Schedule A if a respondent is likely to move within the next six months. If it appeared that he was likely to move, the interview was terminated.

Since these "likely-to-move" respondents were not defined in the sampling universe, other dwelling units in the blocks where these respondents

lived were sampled at random in an effort to build up the level of completed interviews. It turned out that "likely-to-move" households were correlated within their respective blocks and it was not always possible to complete four interviews in these blocks.

Assuming that measures to determine length of residence were valid it is likely that some not-at-homes or refusals would include some people not defined in the population. If so, any non-response bias would likely be reduced commensurately. But, without confirming information, it is safer to state that some non-response bias is likely to exist for the Schedule A interviews, the direction and extent of which are not known.

The Schedule B response rate averaged 86% and effects of non-response bias from reinterviewing sources are expected to be less than that for Schedule A.

II. Completion of coding, key punching and verification.

The response rates represented 673 usable Schedule A's and 579 usable Schedule B's. Efforts employed to transfer the information in these questionnaires to data processing cards were, first, to code the questionnaires according to a predetermined code key. Next, two coders independently checked each questionnaire for accuracy. Third, data were key-punched and verified. Fourth, a print-out was obtained for all data and was proof-read and re-checked with the questionnaires. Fifth, a computer column displacement program was applied and discrepencies sight-checked. Finally, a second computer print-out was proof read and re-checked with the questionnaires.

III. Completion of visibility measures.

Observers in Salem and Eugene, trained by a representative of the OSU Department of Atmospheric Science, recorded seven visibility observations a day while interviewers were in the field in May 1970 and late August - September 1970 and 5 per day in January 1971. Observations were made every two hours on the hour, beginning at 8 a.m. Three observations per day also were made in July, beginning with field burning, and continued until interviewing began in late August. This latter effort was an attempt to establish a visibility baseline prior to the September interviewing. These observations are summarized in Table 3 and 4, pages 5 and 6.

An analysis of these data suggests:

1. For Salem, visual restrictions due to air pollution were greatest in September and least in May and January. Visual restrictions from natural sources were greatest in January when snow, fog and rain limited visibility.

2. For Eugene, visual restrictions due to air pollution were greatest in September and least in May and January. Visual

Table 3. Summary of Visibility Data at 5 Distances for Salem, Oregon

| Miles/Visibility* | | May 1970 (7/14)** | July (3/20) | Aug. (4/9) | Aug. - Sept. (7/20) | Jan. 1971 (5/10) |
|---|---|---|---|---|---|---|
| | O | .98 | .98 | 1.00 | .97 | .82 |
| < 2 | P | .01 | .02 | 0 | .02 | 0 |
| | N | .01 | 0 | 0 | .01 | .18 |
| | O | .98 | .98 | 1.00 | .96 | .56 |
| < 3 | P | .01 | .02 | 0 | .02 | 0 |
| | N | .01 | 0 | 0 | .02 | .44 |
| | O | .93 | .91 | .94 | .90 | .40 |
| < 4 | P | .05 | .09 | .06 | .09 | 0 |
| | N | .02 | 0 | 0 | .03 | .60 |
| | O | .98 | .96 | .91 | .94 | .42 |
| < 5 | P | .01 | .04 | .09 | .04 | 0 |
| | N | .01 | 0 | 0 | .02 | .58 |
| | O | .92 | .91 | .89 | .66 | .28 |
| < 8 | P | .06 | .07 | .11 | .29 | 0 |
| | N | .02 | .02 | 0 | .05 | .72 |
| | (N)*** | (98) | (57) | (35) | (132) | (50) |

Key : * O - Percent of observation marker(s) visible.
P - Percent of observation marker(s) not visible due to air pollution
N - Percent of observation marker(s) not visible due to natural conditions (fog, rain, snow, etc.).

** Number of observations per day/number of days.

*** Number of observation days.

Table 4. Summary of Visibility Data at 4 Distances for Eugene, Oregon

| Miles/Visibility* | | May 1970 (7/13)** | July - Aug. (3/28) | Aug. - Sept. (7/17) | Jan. 1971 (5/10) |
|---|---|---|---|---|---|
| | O | .99 | .89 | .95 | .86 |
| < 2 | P | .01 | .11 | .05 | .02 |
| | N | 0 | 0 | 0 | .12 |
| | O | .99 | .89 | .92 | .64 |
| < 3 | P | .01 | .11 | .08 | .10 |
| | N | 0 | 0 | 0 | .26 |
| | O | .97 | .74 | .76 | .48 |
| < 4 | P | .03 | .26 | .24 | .16 |
| | N | 0 | 0 | 0 | .36 |
| | O | .77 | .05 | .34 | .42 |
| < 8 | P | .23 | .95 | .66 | .14 |
| | N | 0 | 0 | 0 | .44 |
| | (N)*** | (91) | (84) | (119) | (50) |

Key : * O - Percent of observation marker(s) visible.
P - Percent of observation marker(s) not visible due to air pollution.
N - Percent of observation marker(s) not visible due to natural conditions (fog, rain, snow, etc.).

** Number of observations per day/number of days.

*** Number of observation days.

restrictions due to natural conditions were greatest in January.

3. Visibility restrictions due to air pollution in Eugene were greater than in Salem for any distance in September.

It is concluded that visibility in Salem and Eugene was commensurate with expectations prior to interviewing and that the physical effects occurred as anticipated.

IV. Analysis of air quality perceptions of respondents.

Visibility data can be employed to ascertain a respondent's accuracy of perceptions concerning air quality. Accuracy was determined by scoring responses to one question asked during the second interview. In September, for example, this question was:

> "Within the last three weeks, would you say that the air pollution in Salem (Eugene) is better or worse than when we talked to you earlier this year in May?"

Responses to this item were compared to the analysis of visibility observations: a "worse" response in the September interview and a "better" response in the January interview, for example, are considered accurate. Other response codes employed were "no difference" and "don't know" but these were not used to determine perceptual accuracy or inaccuracy. These responses are summarized in Table 5, page 8.

Accuracy of perceptions concerning air quality varied by city (location effect) and time of interview (timing effect). A statistical analysis of the data in Table 4 suggests a highly significant location effect, if one sums the Chi squares and degrees of freedom in Table 4. Switching the independent variables, i.e., controlling for location effects and testing for timing effects resulted in a non-significant Chi square for Salem interviews but a highly significant Chi square ($X^2$ = 28.90, 3df; $p < .001$) for Eugene interviews. Testing for a possible location x timing interaction effect involved the routine suggested by Snedecor[1] and resulted in a pooled Chi square of 11.67, with 3 degrees of freedom, significant at the .01 level. Thus, much of the variation in perceptual accuracy can be accounted for by three effects -- a location effect, a timing effect (for Eugene only), and an interaction effect.

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[1] George W. Snedecor, Statistical Methods, Ames, Iowa: Iowa State University Press, 4th ed., 1946, pp 191-192.

Table 5. Summary of respondent perceptions to air quality between 2 interviewing periods in 2 Oregon cities

| Perception of air quality | May - September 1970 | | September 1970 - January 1971 | |
|---|---|---|---|---|
| | Salem | Eugene | Salem | Eugene |
| | % | % | % | % |
| Accurate* | 53 | 52 | 51 | 72 |
| Inaccurate** | 15 | 31 | 12 | 6 |
| No difference | 29 | 14 | 31 | 18 |
| DK | 3 | 3 | 6 | 4 |
| Total | 100 | 100 | 100 | 100 |
| (N) | (139) | (152) | (146) | (142) |
| | $X^2 = 15.58$, 3df; $p < .01$ | | $X^2 = 13.76$, 3df; $p < .01$ | |

*"Worse" response in May - September interview, "better" response in September - January interview.
**"Better" response in May - September interview, "worse" response in September - January interview.

It had been hypothesized that a higher proportion of Eugene respondents would have accurate perceptions than Salem residents. This stemmed from the notion that living in Eugene, with a prior history of deteriorated air quality in late summer, provided residents with more cues for distinguishing air quality levels and that a change in air quality would more likely impinge on their consciousness. This hypothesis was supported in the September-January interview but not in the May-September interview. Nearly twice as many Salem residents inaccurately perceived differences in air quality for the January interview than Eugene residents; a reversal was found for the September interview. Examination of responses to an open-ended item asking respondents to give their reasons for believing air pollution was better or worse revealed a mixed pattern. These responses are still being studied.

V. Analysis planned for the forthcoming year.

Computer programs have been written to estimate the reliability of multi-item measures of all variables in the model, including the reliability of change scores. Assuming the reliability for all variables is sufficiently high, the next step is to adjust change scores for regression effects (a function of unreliability) before testing the model empirically by two-stage least squares.